PHD

Enlightenment on power: Or a look at the electricity supply industry.

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Award date:
1980

Awarding institution:
University of Bath

Link to publication

ENLIGHTENMENT ON POWER

or

A LOOK AT THE ELECTRICITY SUPPLY INDUSTRY

Submitted by R.G.S. Johnston
for the degree of Ph.D.
of the University of Bath
1980

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ACKNOWLEDGEMENTS

I should like to express my thanks to:-

1. All those helpful staff in C.E.G.B. & U.S. power stations who have provided the data to make this thesis possible.

2. The S.W. Regional Management of the C.E.G.B. for allowing me to carry out the research.

3. Mr G Hutton (Reader in Behavioural Sciences) for his help and guidance during the preparation of this thesis.

4. The typists and support staff for their assistance in the preparation of the material. My especial thanks to Thelma Spalding who typed so many of the field studies and Jeanette Bowering who typed this thesis.

SUMMARY

This research began as a study into working patterns in U.K. power stations, but developed into a comparative study following visits to three U.S. stations.

The jobs and working systems at four C.E.G.B. (U.K.) stations and three comparable U.S. stations have been examined in some detail by conducting a substantial number of interviews. All power stations are technologically similar and differences in structure or systems have to be accounted for by other factors. A work analysis was carried out based on core activities (central to the function); system maintenance and regulating activities and activities intended to effect plant improvements. Diagrammatic representations of the organizations enabled certain problem areas to be predicted. Results were compared with other research in associated fields.

Significant organizational differences were found between U.S. and U.K. stations; the U.S. were task orientated and the U.K. were control or rule orientated. Staff levels in U.K. stations were higher and the total workload was greater. These effects were associated with the bureaucratic nature of the U.K. organizations and a different approach to major outages. U.S. stations were staffed for operation and routine maintenance; C.E.G.B. stations for those activities plus major outages.

A review of the industry's history and development in the U.K. and U.S. showed interesting differences and indicated some probable causes for the present U.K. structures. Also discovered were some similarities between pre-nationalization U.K. stations and present day U.S. ones. The U.K. need for rapid expansion of generating capacity and attempts to improve labour productivity in the industry were two of the main reasons for the present structures, a third being the problems associated with the power station plant and construction.

In this research two subjects were frequently raised by C.E.G.B. staff, namely pay and shift work. These have been treated as special subjects as has the problem of overmanning.

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PART 1

THE SETTING

In which the purpose of the research is explained together with the background and procedures. The locations are described and the methods used are outlined.

CHAPTER 1

BACKGROUND TO THE RESEARCH

Introduction

Presumably the main purpose of an introduction is to explain and amplify the title. In the case of this thesis the title needs some explanation although the need is less in the case of the sub-title. Power generation in England and Wales is carried out by the Central Electricity Generating Board (C.E.G.B.) which is an organization which generally likes to keep itself very much out of the limelight. In the late 1960's, when new power station construction was at its peak, its rate of capital investment exceeded that of any other organization in the country. The heavy electrical manufacturing industry and the National Coal Board are two major industries which virtually depend on the C.E.G.B. for their continued survival. Thus, the C.E.G.B. is concerned with power in both senses of the word. The shedding of a little more light than is normally provided by this light and power producing organization would not come amiss.

Having suggested that the research is concerned with the C.E.G.B. this suggestion must be immediately qualified by saying that the main area of investigation is both smaller and larger than the C.E.G.B. The study is primarily concerned with the organization of power stations which must be smaller than the organizational whole. However, the study is also concerned with overseas power stations and in this respect is larger than a study of the C.E.G.B. alone.

The study was initiated by the author being assigned to assist in the restructuring of the organization of one of the Region's power stations. At the time, it seemed desirable to the author that a study of greater depth than that proposed should be carried out and the Regional Management were agreeable to this being done. They also agreed to the work being used as a thesis subject leading to a Ph.D. degree. A programme was subsequently developed in conjunction with the School of Management at the University of Bath and the study was acceptable to them.

The Management of the South West Region of the C.E.G.B. expected the work to satisfy the short-term needs of power stations as it progressed. In the longer term they are hopeful that the final study will give a useful insight into power station organization which might be of value in determining future policy.

Introducing the author

I am a member of the Regional Headquarters Personnel Department and belong to its Development Section. The Personnel Department carries out various routine aspects of personnel administration such as records, superannuation, salaries etc. Other major areas of work are the co-ordination and management of the staff training programme within the Region and the provision of an industrial relations service by interpreting the Agreements, and dealing with problems by consultation and negotiation. Direct services to the locations are provided in the fields of recruitment, re-grading, manpower planning, and the preparation of job descriptions and organisational charts. Tasks outside these well defined areas are the province of the Development Section and would include investigations in preparation for organizational change, advice on various areas of personnel policy not covered by the other branches and sundry projects without an existing home.

This wide field of work within the Development Section has enabled me to carry out a number of projects of relevance to this research; one major example being an attitude survey at a large power station. However, other tasks have not been so relevant to the research, one example being the preparation of a Personnel Handbook.

My work is under the direction of the Regional Personnel Manager and I am allowed considerable discretion as to how projects are handled.

Regular reporting of progress is expected both by the Personnel Manager and the "Clients" at the power stations who may have requested a particular project.

Before this current research work carried out under the aegis of the University I carried out a smaller study as a part of the work for my M.Sc. This was an investigation into the styles of the management teams in a number of power stations and the result will be referred to in this thesis. That study enabled me to achieve some understanding of the power station organization and also to establish a rapport with the staff at a number of stations. Prior to this, my interests in power stations were in the technical fields since I worked as a Research Officer for ten years in the Scientific Services Department. This work involved frequent periods in power stations carrying out experiments and solving technical problems. It provided a first-hand involvement in the technology of power stations and this too has proved of value in this present research. My earlier background before joining the C.E.G.B. was in the fields of scientific and engineering research carried out over a period of about 10 years at three research establishments.

Background

There were two main strands to the situation within the industry which led to this research and these will be discussed fully later. However, as a part of this scene setting exercise they are briefly outlined here. In the period 1953/63 the average annual increase in electricity demand was 9.4% (Reid and Allen 1970) and this led the C.E.G.B. into a major power station building programme which was suppose to end in the early 1970's. The new stations were technologically a major step forward and involved a very substantial increase in the size of plant items. This resulted in many more technical problems being experienced than in previous eras and the solutions were sufficiently protracted to lead to changes in power station organization. In times past the commissioning stage for a power station had been a hectic six to twelve months in the early life of the new station. This stage now took on a new dimension with the need for substantial engineering expertise which was initially provided by the Headquarters Departments (Scientific Services). The scale of work was such that this was quickly supplemented by specially recruited station staff. The absorbing of the staff into the station structure was the subject of much debate and even of research (Rayner 1974) and it ended up with significant alterations to the traditional power station organizational structure.

The other major factor giving rise to organizational change in power stations stemmed from the introduction of a Pay and Productivity Scheme with its attendant emphasis on work planning. A supplementary aspect of this phase was the adoption of corporate planning within the C.E.G.B. on a much wider scale than hitherto. These changes gave rise to the creation of large planning departments and enlarged administration departments within power stations. In addition, changes and supplementary staff were introduced into other departments to operate the systems and procedures evolved.

As the stations began to settle down to steady state operation some managers felt the need to restructure the organization and it was one such request that led to the initiation of this research. The initial proposal was to examine the organizational structure at similar power stations, but since these were all in much the same situation it seemed more reasonable to look at some of the steady state organizations in power stations elsewhere or other process industries.

To summarise, the industry found itself in the middle of a period of change of greater magnitude than had been anticipated. It was also faced with the second stage of such change, namely the establishment of steady state organizations in power stations able to resolve the technical problems still existing and also able to absorb the elaborate managerial and administrative systems imposed on power stations by national and regional policy. Although the technical problems were recognised by Headquarters management, they did not necessarily see the situation as one requiring organizational change. Initially, only certain power station managers, faced with day to day operational problems, were prepared to define the requirements in terms of such organizational change.

C.E.G.B. Needs

The first requirement that this research had to meet was to provide a service to those power stations which wished to carry out an organizational change. At that time the Regional Management were concerned by the ever growing size of the teams of engineers recruited into the new power stations. This was matched by the numbers of industrial staff growing to levels approaching those before the introduction of the productivity scheme, the main purpose of which was to reduce staff levels and increase output.

The industry was also faced with excess capacity due to the failure of the economy to grow at rates planned in the earlier forecasts. This necessitated a station closure programme which would exacerbate the problems associated with the high staff levels in the new power stations. With no new power stations to absorb them, the industry was faced for the first time since nationalization with the problems of surplus staff. This "no growth" problem also affected the engineering staff who had to re-adjust to the prospect of limited promotion opportunities. It manifest itself in a lowering of morale which led to the creation of an investigatory group at Headquarters. This group subsequently changed its area of interest from engineers morale to the restructuring of power station organizations.

As the research progressed other immediate needs of power stations were met by the research. One was the request to investigate the effects of the organization on the staff at a major power station. When this was completed and reported to the Regional Headquarters the reaction was to ask for proposals for change arising from the research.

In summarising it might be said that the defined C.E.G.B. needs of this research were to provide services to power stations in the fields of organizational change and to attempt to draw some overall conclusions which might be of longer term benefit to the industry. This rather imprecise need might be explained by the proliferation of specialists and systems at Headquarters giving rise to a general feeling of work going on which was no longer directly related to the perceived task of managing a group of power stations. This feeling is nicely expressed in the picture of organizational growth given by Leavett, Dill and Eyring (1973) ....."(Managers)wished that such problems would go away so they could concentrate on the job".

The purpose of the research

Perhaps a brief statement about the motivation for the research should preface the discussion about its purpose. I am not undertaking this research with a view to financial or promotional gain since I am too old to entertain desires in that direction. The motivation is more associated with a way of life; having carried out research for the whole of my working life (nearly 30 years) I am perhaps becoming indoctrinated in the belief that learning is living. Furthermore, I believe the discipline of academically direct research is much more satisfying than the easier option of putting across a few ideas to a management who, perforce, have limited horizons in a particular field. This might explain my initial request to management to allow the proposed comparative study of a couple (or so) of C.E.G.B. power station organizations to be expanded into a more rigorous study of those organizations in the context of organizational theory. Having thus attempted an explanation of my motivation, what about the defined purposes of the project?

In my previous research (Johnston 1973) the styles of the Management teams in thirteen power stations were studied and some conclusions were reached. Certain of these conclusions had implications for the rest of the organization (e.g. the extent to which direct contact was established between management and the work force). Another conclusion was that differences in managers working patterns depended on the management style adopted by the Station Manager. This finding accorded with the subsequent work of Rosemary Stewart who suggested (Stewart 1974) that not enough attention is paid to the differences between managers jobs. Power station organizations lend themselves to such studies because the number of variables is greatly reduced and some are nicely controllable:- e.g. technically similar power stations in two countries can be studied.

Another important area of investigation was the increasing complexity of power station organizations with the proliferation of management systems (e.g. short term planning and method study) requiring specialist groups of staff. The question posed was whether the organization was becoming unnecessarily complex (or bureaucratic) in relation to its objectives. Was the ratio of "chiefs to indians" getting unbalanced? Was an excess of procedure and paperwork distracting attention from the main function? As Drucker (1974) points out - together with many others - "structure is a means for attaining the objectives and goals of an institution". A supplementary question raised by the increasing organizational complexity was the possibility of increased alienation as administrative systems replaced delegated direction and decision making. Systems such as the Pay and Productivity work procedure could be regarded as a re-emergence of Taylor's scientific management and a reversal of other recent trends such as those popularised by Herzberg and reported in various studies. A related example being the increased output of aircraft maintenance workers when given a greater delegated decision making power. (Davis & Valfer 1965).

Discussions and evidence all pointed to a decline in the morale within the industry in the period immediately preceding this research and this also co-incided with the 500 M.W unit era. Headquarters direction and decision making appeared to increase and the one certain fact was the absolute increase in Headquarters staff numbers. Throughout the research the status of nearly all the Headquarters staff was extremely low in the eyes of power station staff and in their own perception. The general feeling was that the Regional Headquarters was a large and ineffective organization suffering from some of the faults outlined in the study of the U.S. Department of State (Argyris 1967). The research project would look for evidence to support this belief or discount it.

The general purposes of the research project at its instigation could be summarised as follows:-

1. To relate the increasing complexity of C.E.G.B. power station organizational management systems to the current plant needs.

2. To make comparisons with parallel progress in overseas power stations.

3. To study the effects of such managerial systems on the members of the organization within power stations.

4. To test the thesis that alienation increases as management and administrative systems become more complex, replacing direction and decision making at the working level.

5. To produce some evidence that as organizations become larger and more complex they also become less effective.

Programme and Changes

The programme as initially set out was fairly straight-forward and and involved a study of the organizations within three C.E.G.B. power stations, followed by a visit to two American power stations. This was to be accompanied by a study of the power station organizations in other countries insofar as information was available in reports. The whole of this information was to be related to the literature and research on organizations, particularly that covering similar types of organizations.

The first stage of the programme started with the analysis of engineers jobs at the power station undergoing change. All the existing jobs were analysed together with a similar range of jobs at another power station. At the end of this stage the programme was to re-organize the work, creating changed posts in a new organization. This stage had just got underway when a setback occurred arising from the work of a London based group investigating the morale of engineers within the industry. This group had switched their attention from morale to the organizational structure in power stations as it effected engineers. The group recommended the adoption of a new organizational structure in all large U.K. power station which was to be introduced in one power station per region as an initial exercise and subsequently to be extended to include all others. The system had been tried in two large U.K. power stations and these were visited by the group before making the final recommendation. Furthermore, the same organizational framework was to be adopted for the departments in all the headquarters of the C.E.G.B. (five regional and London Headquarters). The station which was the subject of my study was also chosen by this group as the Regional prototype. As a result, the engineers at this power station suggested that my work be suspended pending the outcome of the London group's work. Arising from this change my work was directed towards the other two stations being studied, but before that work got underway a visit was arranged to two United States stations. This was planned as a part of my holiday in the summer of 1976 and arrangements had been made to visit the Tennessee Valley Authority (T.V.A.) Headquarters and two of their power stations. In the event, these visits were carried out (limited to two days each because they were part of the holiday). In addition I made contact with an engineer from the Duke Power Company and through him arranged a visit to one of their stations. An attempt to visit another of their stations (the one at the top of the U.S. merit order) was discouraged by that station's Administration Officer because it was vacation time and they were under some pressure. He suggested it was not worth an additional visit because its organization was the same as the one I planned to visit. So I did not push my luck.

These visits represented another point of inflexion in this study because the organizations were so significantly different that the explanation of these differences had to become a major part of the investigation thereafter. The visits also amply justified my original request to extend the research project beyond the C.E.G.B. power stations.

On my return,the study of the duties and systems at the two original control stations was continued and parts of the research were being assembled by making studies of information relating to other power stations. These other stations were mostly overseas since information about C.E.G.B. power stations in other regions is very difficult to obtain. The tentative programme at this stage was to write-up the research and draw some conclusions ready for presentation in the middle of 1978.

The next substantial change arose from a request to carry out an attitude survey at a large station (largest) within the Region. The request was that I interviewed a cross-section of all the staff on the station with the exception of the administration. I was to obtain opinions on the work, the organisation and the management style. The main concern of the management was the high staff turnover rate coupled to an inability to recruit enough skilled staff. There was also a belief that morale was low on the site. The study commenced in the summer of 1977 and interviews began in the autumn. These were delayed by two strikes (not connected with the research) but were finally completed the following March. The report was then compiled and presented to the management in September 1978. Thus the whole project lasted a little over one year and, although it delayed this final thesis, it provided a first class insight into the way a power station operates. It also provided much of the data which forms the subject of Part 2 of this report.

Following the survey, there were a number of projects carried out some of which were not relevant to this research but were designed to be of use in power stations. Some of the findings of the attitude survey were made known to the staff (only the Station Manager had the full report) and the staff requested assistance in correcting deficiencies. Arising from this request a Personnel Handbook was produced which was intended to deal with some of the procedural gaps that had become apparent during the survey.

The final stage in this research programme was to obtain some further information from the two control power stations and set about the preparation of this final report. Although completion was scheduled for October 1979, other work assignments have led to further delays of a few months.

Outline of Thesis

The thesis is presented in four parts and this, the first one, covers the mechanics of the research. In the next chapter (2) some background information about the power stations studied is presented together with diagrams of their organizational structures. The final chapter (3) in this part of the report covers the interview methods used at the various station studied and the numbers of staff involved.

In Part 2 the research findings are presented. The form of presentation is as a series of descriptions covering various aspects of power station work. These descriptions attempt to build up a picture of the work and the systems in power stations and to show some of the contrasts in these patterns between technically similar stations in different countries. Power station technology is briefly outlined in Chapter 4 and followed by four chapters on working patterns. In these the idea is introduced of relating work to its directness of applicability to electricity generation. Chapter 5 describes the core generating activities associated with operating the plant and short term maintenance. In Chapter 6 plant maintenance systems are reviewed which are all directly connected with the continuous functioning of power stations. These supporting functions are limited to those necessary for the technical operation of the plant.

The many areas of work in a power station intended to make the organization more efficient or to improve the effectiveness of plant operation are discussed in Chapter 7. These are defined as regulating activities and include those necessary for the maintenance of the organization itself. In Chapter 8 those groups, tasks and systems in power stations which are intended to improve the effectiveness of the plant are reviewed together with some of the Headquarters groups engaged in similar functions. In Chapter 9 the power stations are compared as entireties and areas of dissonance are uncovered. Also in this Chapter the research is related to the published work of others in the field and some conclusions are drawn.

The main theme of this research is the power station organizations, but much of the information obtained relates particularly to the lives of the individuals who comprise the staff of power stations. This material is presented as three ancillary studies in Part 3 of this thesis. They are not intended to be complete research projects in their own field and it is highly likely that comprehensive research into any one of these topics would be more extensive than the work presented in this thesis. In Chapter 10 the subject of shift work is discussed within a framework provided by the opinions of many of the staff interviewed during the research. It is a subject of considerable interest to the C.E.G.B. and many other process industries.

During the attitude survey (at a time of strikes for more pay) the topics of pay and allowances often arose and some of my investigations into the subject are reported together with some rather surprising conclusions. It is possible that similar findings could arise following parallel investigations within other industries and that, if so, the significance of the findings for industrial relations in this country would be considerable. This material forms a subject of Chapter 11.

The final chapter in this part of the thesis is a brief discussion on some aspects of overmanning. This is put forward in the belief that any research into organizations should responsibly consider the likely outcomes. In various ways this research into power station organizations indicates a degree of overmanning in C.E.G.B. power stations. Since many other industries in this country at this time are coming to similar conclusions it is evident that the problems of overmanning (and unemployment) must be considered. This has been attempted in Chapter 12 but only to the extent that a possible way out is discernable and I leave it to others to follow that trail.

The analysis of the power stations in Part 2 leaves unanswered some questions as to why the differences exist between the C.E.G.B. and certain overseas power stations. Before attempting to answer these questions in the final chapter it will be helpful to fill-in the background to the industry. This is presented in Part 4 of the thesis and starts with the technical history in Chapter 13. The development of the industry in the U.K. with some emphasis on those factors which affected its form and progress provides the subject matter for Chapter 14.

The parallel development of the U.S.A. Electricity Industry is briefly outlined in Chapter 15 and a few comparisons are made with U.K. developments.

Finally, changes in the organizational shape are traced from the early beginnings and some comparisons made in Chapter 16 between pre-nationalization U.K. stations and present day U.S.A. stations.

Chapter 17 is the last in the thesis and draws on the evidence presented in Parts 3 and 4 to answer some of the outstanding questions raised in Part 2.

The appendix provides much of the basic data derived from the power station studies in the form of work schedules and tables.

CHAPTER 2

THE STATIONS STUDIED

Introduction

The research was carried out at seven power stations. At each one the primary aim of the research was to understand the organization or at least to deal with substantial sections of it. The emphasis of the research varied from station to station because of a need to meet the specific requirements of the C.E.G.B. (such as the restructuring exercise already referred to). Generally, the studies at the U.K. power stations were detailed in their particular areas but less specific information was obtained about other aspects of organizational life in these stations. The studies in the United States power stations were not so detailed and in all cases were the views of certain individuals as to how the organization worked. Generally these were the managers and in only a few cases were discussions held with industrial staff because of the time limitations.

The information given to me at these United States power stations was not restricted in any way and there is no reason to attempt any disguise of these stations. However, within the C.E.G.B a general air of secrecy prevails and in certain cases identification of the source of information would not be permitted. It seemed best, therefore, to avoid naming any of the C.E.G.B. power stations; but to enable the reader to build-up a better mental picture they will be given fictitious names. Each of the stations will be profiled in turn and any available items of relevance about managements style etc. will be included where possible.

Downton Power Station

The power station at which this study was carried out is a 2000 MW four unit coal fired station. It is situated in a pleasant part of the English countryside and relies on a river for cooling water. At the time of the study the station was fully commissioned but a major problem had arisen on one unit and the station was facing serious shortcomings due to design failures. Lesser commissioning troubles had resulted in a total loss of output on the three available units of nearly eight million MW hours (nearly two years operation for one 500 MW unit) in a very short operating life. Furthermore, the performance of the three units was well below that planned; for example, capacity was 12.5% down, output 27%, load factor 19%, availability 29% and thermal efficiency 9%. Thus the station was suffering from many of the typical problems besetting most of the 500 MW units in the C.E.G.B.

The overriding need at that time was to resolve the technical problems on the plant and by 1974 thirty-six modifications had been carried out, many faults had been corrected and eighty-seven further modifications were underway. The creation of a Development team was being actively considered and the various organizational structures created by other power stations to tackle a similar situation were being examined. The main choice lay between a temporary group to be subsequently disbanded or a smaller permanent group to be incorporated in the overall organization. Despite these problems the major emphasis of the station was on steady state operation and the achievement of improvements in performance.

The station was one of those studied in my previous investigation of power station management teams. That study was carried out during the initial commissioning phase of the first units when the working patterns were significantly different from those prevailing in this study. However, the management style was unchanged. At the time of the previous study the management team were working under considerable pressure for long hours. Of necessity they delegated extensively and most of the work was non-routine in nature. The management team existed as an entity and policy was jointly determined. Although the Station Manager had one or two autocratic foibles, a consensus was generally sought in a solution of problems. At that time there was a general feeling that meetings and discussions were too extensive and a belief by some that information feedback was not always successful. The management team then considered their work to be fairly evenly divided between professional engineering and management. Industrial relations on the site were considered to be moderately good but capable of improvement. Some departmental managers hoped to be able to spend more time on these aspects of work when the commissioning pressures eased. The Station Manager believed in management information systems and also that effective training at all levels of staff should be encouraged. The facts in the previous research showed that this station spent less time in meetings and discussions and more time on individual effort than most comparable ones. The Station Manager and his Deputy maintained an "open door" policy. Problems and projects were often allocated to senior managers in an apparently random manner and the overall objective of the whole team was always clearly understood to be the successful commissioning of the station. This requirement took precedence over departmental needs.

The foregoing data provides a background to this study which was to discuss and write descriptions of the jobs of all the engineers and administrative staff at the location. This involved discussions with over eighty members of staff. In addition to these a series of subsidiary discussions were held about attitudes and working practices at the location. All the tasks performed by the engineers were broken down into their component parts in order to determine the managerial, supervisory and technical content of each task and also to determine the urgency "time-scale" for each task. This information was summarised and has been used to provide data for the composite sketches of power station life presented in Part 2 of this report.

Olliton Reach Power Station

This station also has four 500 MW units (plus gas turbines) but this station is oil-fired whereas the previous one was coal-fired. Also, this station was two years earlier in the construction and commissioning programme. Design and "teething" problems had also troubled this station and led to a prolonged commissioning period. It had not suffered the major set-back of the loss of a unit as had the previous station. To resolve the more fundamental faults a temporary Development group had been formed under the control of the Deputy Station Manager with a planned life of two years. In the event, it existed for three years before being disbanded having solved the major problems. The remaining development work was then transferred to a permanent Development department which existed at the time of this research.

This station was therefore entering the steady operating era and the Station Manager considered it to be an appropriate time to consider organizational structure changes. The major effects were expected to be on the professional engineering staff and a working party was convened comprising members of the management together with engineers representatives. This working party identified a number of areas in the existing structure where improvements were necessary and final proposals for the re-organization were prepared by the Station Manager. The proposed outline structure comprised a Production department, together with Engineering Services and Management Services departments. The Development department was to continue for a further five years on a diminishing scale. The benefits from such a re-organization were defined by the Station Manager and most were improvements in existing management systems. One was the resolution of a specific organization problem and only two directly brought about improvements of the organization in relation to plant requirements.

This station was also one studied in the previous research project and some of the findings relating to this management team are still relevant for this research. The station progressed from being half commissioned to being fully commissioned during the period of the previous study. At that time all the members of the management team worked long hours under considerable pressure and were subjected to frequent interruptions. Changing circumstances and work requirements made it difficult for the team members to plan or organize their work. Most of the policy formulation material was generated by the Station Manager (sometimes in consultation with his Deputy) and this material formed a large part of the agenda for the team meetings. Delegation was practiced by the team with the notable exception of the Deputy Station Manager. More than two thirds of the team members time was spent in discussion and even then they considered that feedback of information was inadequate. Most of the team members felt the need for more time on creative thinking and only averaged 10% time on all solo activities.

One major factor emerging from this previous study was the discordant note within the management team due to one member holding views on many topics at variance with those of the remainder of the team. The individual was a "loner" by nature and did not work well within the team. He also disliked having his decisions as Departmental Head modified or varied to suit the needs of other departments. This led to a lack of co-operation between departments and to a less effective organization. This resentment by the individual partly derived from the rather autocratic style of the Station Manager and the unwillness of the Deputy to delegate which tended to usurp his role as Departmental Manager.

The background to the proposed re-organization (the subject of this study) must be viewed with this situation in mind since the proposed re-organization included the elimination of the department managed by the "loner". He was to be allocated the Development Department in the restructuring and, as already mentioned, this department was planned to be phased out over about five years. Subsequent to this study, but before the re-organization had been completed, the individual was promoted out of the station. It is also interesting to note that although the re-organization has been carried out, the new Production and Engineering Services Departments created have reverted to carrying out the functions in the form of Operation and Maintenance Departments.

The original idea of amalgamating the two functions into one department has been dropped.

The study that I was required to carry out at this location was to identify all the tasks performed by the engineers and to re-allocate those tasks in accordance with the re-organization proposals. Discussions were held with departmental and section heads only (as specified by the Station Manager) and information on 110 engineering jobs was obtained. All the existing jobs were reviewed by the Station Manager who indicated those areas, tasks etc. where changes would be desireable. A start was made on the restructuring of jobs and the framework for the new organization was identified with the functions of each section being defined. At this stage the proposals of the London Headquarters team brought the study to a close. Incidental to this study, and arising from discussions with many of the staff, a great deal of information on attitudes and working practices at the station was obtained. Some of this was valuable in presenting a picture of operations and maintenance practice in power stations.

Fossil Strand Power Station

On this site are two nuclear stations and during the research period the older station (magnox) was on base load and the new one (AGR) was at the commissioning stage. A number of separate research projects were carried out at this station over an extended period of time. An early study involving discussions and analysis of the work of 70 administrative staff arose from a request by the Station Manager to assist in the re-organization of the Administration Department. Arising from the study a number of changes were made within the department.

Another study at this location arose from an Award by an industrial tribunal of a special bonus for engineers on the location whose duties involved work on both stations. This was to compensate for the additional efforts associated with working on two types of plant and the Award involved considerable sums of money. To service this Award the duties and patterns of work of substantial number of engineers on the site were analysed by a Union representative and myself. The study gave some further insight into the patterns of work on the location and incidentally it established that the principle underlying the Award was exactly reversed in many cases. (i.e. Working on two stations simplified duties by duplicating an identical task.)

These two studies were supplemented by discussions with staff members at all levels within the organization to establish attitudes in relation to the organization, work and industrial relations. Two minor investigations were also carried out into the working patterns of groups of staff who had made requests for organizational changes. An "in depth" study was carried out on a small group created to tackle some of the outstanding technical problems of the older station.

Two substantial, but different, groups of staff were studied "in depth" each having a high degree of autonomy. The first was the Development Team comprising thirteen engineers and operating independently of most other parts of the station's organization. Most of its projects were carried out by the use of contractors and the methods devised to handle projects were an integral part of this research. The other major study was an investigation into the working patterns, attitudes and opinions of the whole of the Electrical Maintenance Branch. This comprised a total of 117 staff and included managers, engineers, foremen, craftsmen and mates. All the engineers and foremen were interviewed and over a quarter of the fitters and mates. A representative sample of the total workload was analysed in depth and the opinions of the industrial staff obtained in relation to these tasks.

The station was not included in the previous study and a few details about the background might be appropriate. A frequently recurring difficulty in power stations is that of fully integrating the shift staff into the general life of the station. This location was unusual in that the shift engineers on the older station were alienated from the rest of the station's senior staff. This situation arose in the early days of the station's life as a result of personality clashes on some allegedly unfair promotions. Industrial troubles and disputes had always had a sharper focus at this station than most others and these factors were not helped by the original Station Manager adopting an autocratic style and remaining comparatively remote from the workforce. At one time industrial unrest led to a deterioration of critical parts of the plant and the resultant operating difficulties were finally resolved by the provision of additional plant at substantial expense. Another problem on the site arose from the failure of Regional Management to appoint a separate team for the commissioning of the new station. The long timescale for the commissioning of the new station led to it being denied resources which were preferentially directed to the ongoing station with its much shorter timescale of need. At a very late stage there was a very frantic switching of resources and the jockeying for senior positions. This coincided with the period when the economic importance of the new station vis-a-vis the old station was beginning to be realised. Also at this station the working practices adopted by some of the industrial staff were both counter to efficient operation and to job satisfaction. They were maintained because they were considered to be bargaining factors for special payments.

This location is especially interesting because many of its problems derive from poor communications and poor management (despite the presence of some able managers). The links between cause and effect have been traced in a number of cases.

Ash Haven Power Station

This was another two station site. Both stations were coal-fired although the older station had been partially converted to oil-firing. The new station comprised three 500 MW coal-fired units and at the time of the research part of it was still being commissioned.

The research requested for this location was an attitude survey with the primary purpose of trying to identify the causes of dissatisfaction amongst the staff. Where possible the management wished to rectify the dissatisfactions so as to improve morale on the station and reduce the staff turnover rates. These were an average of 17% for craftsmen with a high value of 30% for instrument mechanics associated with considerable difficulty in recruiting replacements.

At the time of the study there were nearly 200 engineering staff in post and approximately 900 industrial staff. The administrative staff were not included in this study because their turnover rate was not a cause of concern for the management. Approximately 25% of the engineering staff and 15% of the industrial staff were interviewed by random selection from the various groups of staff on the site. Such grouping ranged from the Management team to the cleaners and labourers. The survey covered the working patterns and opinions of individuals over a series of topics relating to the work.

This survey comprised the largest single study in the total research and gave a valuable insight into the total working patterns for a power station. Although the omission of the administrative staff at this location might be a cause for some regret it is compensated by the study of two such groups at other stations. The opinions of a number of administrative members of the staff were obtained at this station but not in a systematic way.

The fortunes of this particular site varied dramatically and might account for some of the attitudes found. The original power station was one of the most efficient in the country for many years and at that time the management style was direct and paternalistic. There appeared to be a considerable pride in the station by the staff and the plant was maintained in top condition. The new station was also managed by the existing station staff (in a like manner to Fossil Strand station) and probably suffered in a similar way as a result. During its construction the new station was beset by extensive industrial unrest on the part of the contractual staff. Shortly after its commissioning the first unit suffered a major catastrophe and the turbo-alternator was wrecked. The Station Manager in post at that time (who had previously been the Deputy) was held to be partially responsible for the catastrophe together with other members of his staff. The inquiry considered the catastrophe partially attributable to failures in the organization. A new Station Manager was appointed and he quickly created an almost entirely new management team. The new management style was more remote and extensive changes were made within the organization. A second major catastrophe, similar in nature to the first, wrecked the third of the 500 MW turbo-alternators. Paralleling these disasters on the new station were lesser misfortunes on the old. These were due to changes in Board's Policy it being advantageous to convert older coal-fired stations to oil-burning in the era of cheap oil. This process had been partially implemented at the time of the Suez crisis and the remaining coal-fired plant had been allowed to run down. The policy was dropped following the Suez crisis but no refurbishing of the old coal plant took place. Thus, for a number of years before this study took place both the old and new stations had been technically at a low ebb and this situation probably influenced the results.

T.V.A. Headquarters and three U.S. stations

The first visit of the series to the Headquarters of the T.V.A. at Chattanooga. Discussions were held with the staff members in Personnel, Maintenance Services and Operational Planning. The H.Q. organization and some of the working systems were explained together with information about the systems used for buying and selling electricity from other corporations, the training methods and the salaries structure.

The next visit was to Sequoya Nuclear Power Station which was still under construction but approaching the commissioning stage. The station comprises two PWR reactors and two 1150 MW turbo-alternators. Discussions with all the members of the senior staff providing an insight into the organizational structure and working systems at the station. Other information was obtained about the links between the station and headquarters and some of the systems and procedures that were adopted for the operation of the plant.

The other TVA station visited was the Bull Run coal-fired station. Talks were held with a number of staff and the duties and systems operated in the station were explained. At that time the station was top of the United States "Merit Order" having the highest efficiency and lowest costs. It held the position for several years. At this station the discussions included one or two talks with the industrial staff.

Marshall Plant belonging to the Duke Power Company was visited. It was considerably older than the others and had followed the United States practice of adding further units to an existing station which is similar to the C.E.G.B. procedure excepting in the latter case it is normal to provide the new plant in a separate building. The two original units at the Marshall Steam Plant were commissioned in 1965 and were each of 350 MW's. The two new units were commissioned in 1969/70 and each was 650 MW's. This station had held the position of being the most efficient coal-fired station in the United States for nine consecutive years and only lost its position to the Bull Run Station and to the newer coal-fired station (Bellews Creek) which had just been commissioned by the same company. At this station discussions were held with all the senior engineers and with members of the operational staff. Also a visiting engineer from Headquarters joined in the discussions and explained the role of Headquarters Construction Division in carrying out major modifications on the plant. The organization and working methods of the station were explained as was the overall organization within the company.

Information from other sources

Under a staff exchange scheme certain members of the C.E.G.B. are enabled to make visits to overseas power stations and it is usual to write a report on their return. Generally such visits concentrate on technical aspects which have little relevance for this research. However, one or two were found which gave useful insight to the organizational structure of several overseas power stations and these have been drawn upon as appropriate.

Another of my duties associated with the restructuring of the Regional Headquarters was to prepare a series of job descriptions for the Branch Heads of all the new posts to be created at Headquarters. A study was made of the degree of overlap between these Headquarters functions and the parallel functions carried out within the existing power station organizations.

The remaining part of the research into power station organizations comprise a study of the various documents produced by various bodies and available at the London Headquarters. Very little of this information related to working patterns or practices and mostly it comprised of statistical data on staff numbers etc. Some of these data have been used in the analysis carried out in Part 2 of this report.

CHAPTER 3

RESEARCH METHODS & COMPONENT STUDIES

Introduction

The research was primarily based on information obtained from field studies at the four C.E.G.B. power stations. In this chapter the purpose, extent and methods used for each of these projects is outlined. In addition to these major blocks of research, smaller studies were undertaken notably at the United States power stations. Visits to C.E.G.B. Headquarters and several libraries yielded secondary information of value in this research and one or two visits were made to outside bodies to obtain specialized and confidential information at first hand. Most data arose from discussions with staff in power stations and probably as much as three quarters of this came from interviews with individuals about their own jobs or opinions about matters relating to the organization. The rest of the information was provided by supervisors at various levels describing subordinates' jobs and organizational systems or giving opinions on attitudes at the station.

Throughout the research a constant theme was the work of individuals and the way it fitted into the station's organization and two basic types of interview were adopted. For discussions about jobs there was little need for confidentiality and this allowed a more direct approach to be adopted than was possible with the attitude survey studies where opinions were required on a range of topics relating to the organization. The interview techniques and the method of handling of data are described in this chapter together with information about the extent and type of research carried out at each location.

Preparation of Job Descriptions

Job descriptions are the normal way of presenting data about an individuals job. They should aim to present a clear picture of what a post holder is expected to do in a certain post and what attributes and demands are expected of him in carrying out those duties. On these criteria job descriptions should be prepared in conjunction with supervisors since they are in the best position to know what is required. In practice, the person doing the job is often in a better position to know what is actually involved in a job and particularly such things as the everyday variations and deviations from formal procedures and the necessary links and communications. As a result of these considerations I generally prefer to hold interviews with job holders for ongoing jobs and with the supervisors for jobs associated with change. In either case the resultant description would be checked out with both persons.

The format adopted for most job descriptions was; title page, summary and preface explaining the general purpose of the description: namely, to provide part of a Station organizational manual to be subsequently supplemented by studies of the functioning of component groups within the Station. The preface also explained that the information was not a mandatory statement of tasks, responsibilities etc., but that these could be varied in accordance with employment agreements. This type of statement was required by some senior managers to ensure that documents were not used to define boundaries to working practices. The main part of the description started off with diagrams showing the position of the post within the organization. This was followed by a statement of the objectives of the post, usually limited to one or two sentences. In the earlier studies this was followed by a list of tasks carried out with estimated percentages of time alongside. Some of the tasks were specific, e.g. attending a daily meeting, others were composite such as:- investigating technical problems on the plant at various times during the day, taking measurements, carrying out tests, reviewing recent operating data. In some of the later studies the percentage times for each task were analysed in terms of the proportion spent on management, supervision, theoretical engineering, practical engineering, technician work and administration. This was done to quantify the various inputs of skill required to operate the power station. No attempt was made to obtain precise percentages for the tasks, the purpose being to give some weighting to them. The next three sections of the job description were fairly brief and rather formal statements of responsibility, authority and accountability. These were followed by an outline of the abilities needed for the job and the likely demands of the job on an individual (including staff supervised). The earlier job descriptions included an Appendix giving a narrative and descriptive outline of the job (the Station Manager wanted formal job descriptions and this was a compromise). Later job descriptions used a narrative description of the job at the front where it was intended to provide enough information for most readers without recourse to the more formal parts.

Interview Methods

Because job description interviews were not regarded as confidential they were usually held in the post holder's office and sometimes were subject to a number of interruptions. These interruptions often presented an opportunity to write some additional notes and were not always unwelcome. I attempted to create a very different atmosphere for attitude survey interviews.

Job description interviews These generally started with confirmation of the organizational structure and moved to a discussion of the post holder's definition of his objective in the post. The talk then progressed to the list of tasks and I usually tried to base this discussion on a typical day. For each task I would ask for estimates of the length of time spent on it (either per day, per week or even number of days per year). These estimates were then converted (by me) into percentages and noted against the task. More often than not the number of identifiable tasks range between 12 and 20. It tended to be greater for the senior posts, usually because of the various meetings attended. Also senior staff were often able to produce this information by reference to an appointments diary. Associated tasks were grouped when possible but the occasional interview arose where someone might say that 4/5ths of his day were spent on the plant dealing with technical problems. Such "blanket" answers were usually analysed further to obtain a picture of how the problems were dealt with, types of problems etc. I would also ask whether any work was done within the post holder's own time such as reading technical journals at lunch time or taking work home. During the discussion I would surreptitiously total the percentages to get some idea of whether the overall picture held together. At this stage there was often a shortfall in total time and a review of the task list generally produced some less frequently recurring tasks or groups of small tasks which had been overlooked. The frequency of interruptions during the interview often suggested ways in which the post holder's time went. If the interviewee was aware of my keeping a percentage tally he would generally believe that the total was a long way short of 100% and this thought was not discouraged as it led to a mental search for more tasks. However, I was surprised by the frequency with which the final figures approximated to a full working week without any adjustments. Values of around 110% being commonplace.

The discussion then moved on to authority etc., this stage was generally covered rapidly with me guiding the interviewee. The suggestions led to corrections being offered e.g. the extent of a responsibility. Also any special responsibilities would be covered, e.g. for aspects of safety. Authority and accountability often led to discussions about the organizational hierarchy and on several occasions it transpired that groups of staff were not aware of the actual authority structure as it affected them. Requirements for the job were then discussed and for this I had a formal set of questions covering each of the five areas. These were:-

(a) Training:- level of training and length of experience in a similar or immediately subordinate post.

(b) Initiative:- the degree to which the post holder was expected to use judgement and the closeness of direction of his work.

(c) Responsibility:- the likely effect to the station of any errors by the post holder. Any requirement for tact etc., any need for confidentiality.

(d) Job conditions:- actual physical conditions for the work and any special requirements, e.g. manual dexterity.

(e) Supervision:- whether responsible for a working unit. Whether deputizing for a senior. How many others supervised.

At one stage in the research, I carried out a series of ratings on the jobs with the intention of making some comparisons. But when the Board proposed to carry out job evaluation on a national basis the staff became very suspicious of such questions and I decided to drop the 'requirements for the job' section. I could then assure people that my interviews were not for any job evaluation purposes.

The final stages of these interviews were a discussion on background aspects of communications, contacts and a general confirmation of the main pattern of the job, e.g. that a person spent most mornings at meetings and most afternoons on the plant. At these stages some topic often arose on which the post holder would express opinions, e.g. industrial relations and much useful information for the research was obtained in this way. I either made a few brief notes at the time or dictated some fairly soon after the meeting. A typical interview would last 1-1½ hours and dictating the job description would take an additional hour. Usually I tried to get the dictation done the same day or the next. Any later and the job description became much more formal because the background information had become blurred.

Attitude survey interviews These were different and were held at 2 locations. An undertaking of confidentiality was given and this precluded anyone from being present or seeing the interview notes.

The only exceptions to this were the presence of the Union representative for the first few engineers' interviews in order that he could be in a position to reassure other engineers about the nature of the discussions. Interviews were held in a room set aside for the purpose and therefore free from interruptions. The main intention of these interviews, which were programmed to last for 1 hour, was to get people's opinions about various aspects of power station life. Therefore, I regarded it as my job to put the individuals at ease and then offer a range of topics likely to trigger such a discussion. With the need to break the ice (and some staff were very uncertain and even overawed by the occasion) the discussion opened with the person's position, grade and job being confirmed. Usually I would already have obtained information about the type of work, sequence of duties etc., and I would throw these into the discussion for confirmation and amplification etc. This would often lead on to the type of work preferred by the post holder and why. I would then ask about length of service at the power station and either seek opinions on changes or discuss previous jobs and the differences, preferences etc. By this time there should have been many opportunities to get a topic under way. Subsequently I would cover areas such as working conditions, supervision, discipline, management, pay, overtime, use of contractors, promotion prospects and future intentions. Other related subjects were included such as social aspects of work, housing, travel etc. The survey was held at a time when recruitment for overseas oil companies and new work opportunities in the area made the job changing a real prospect for many staff.

In only about half a dozen cases out of the 186 interviewed at Ash Haven did I find the interview almost impossible to get going. These were generally quiet and older men who remain overwhelmed throughout and answered questions politely and formally, but never expressed any views. In such cases a series of questions was asked and answers noted, but little of value was obtained other than establishing the probability that the individual was reasonably content, probably a steady 'work horse' and not likely to leave. Many people expanded on a particular theme and these would be followed up giving insights into many areas. Analyses were worked out with some of those interviewed on such matters as how their pay was spent. In these cases I had the belief that the information given was accurate and fair, e.g. cost of housing. The only topic I did not get to hear very much about was "moonlighting", although I asked a number of leading questions. Many of the interviews greatly exceeded 1 hour and especially those programmed for the end of a working period. Some expressed scepticism as to the value and outcome of the study, but a fair number welcomed the chance to express their views and were pleased that management had provided the opportunity.

The smaller (and earlier) attitude survey at Fossil Strand involved only 82 staff and was based on a more structured approach. Opinions were obtained in seven areas of interest which were:-

(a) Level of responsibility:- whether they were given sufficient responsibility in their jobs.

(b) Adequacy of information:- were communication systems on the station adequate?

(c) Relevance and pressure of work:- views on present work and whether they would prefer changes.

(d) Congruance of skills and duties:- whether their work matched their abilities and training; would they like more demanding work?

(e) Status and role:- how did they view their position and work in the organization and how did they perceive others as viewing them?

(f) Social needs:- were these met at work and to what extent did work influence their private lives?

(g) Work satisfaction:- to what extent did their job satisfy them and what were the causes of any dissatisfaction. How could work be made more satisfying?

For both sets of interviews, notes were taken during the interview and the report was dictated as soon as possible afterwards. A typed copy was given to the individual and any subsequent modification or additions were made to the text which then became the raw material of the analysis.

The methods used for selecting the interview sample and the way in which the interview reports were correlated and analysed will be discussed in the following sections describing the research projects carried out at each location.

The Field Studies

In Chapter 1 I outlined what I hoped to achieve in this research and what my employers expected of me. In Chapter 2 I have described the background to the stations studied and included some of the problems besetting them. I also briefly described the work I carried out at those locations in the context of the expectations and problems present. Some of those studies, and particularly the attitude surveys, need further amplification in order to clarify the nature and extent of this research. Before giving these details the reader might find it helpful to have a list of the studies carried out which together constitute the main input for this research.

The list of component studies in Table 1 gives an indication of the very large number of interviews carried out in support of this research over a period of approximately six years. The information obtained together with that from informal discussions with station staff members has served to provide a series of impressions about power station life which I shall endeavour to analyse in this thesis. The only substantial block of additional information about research methods relates to the Ash Haven attitude survey but I think it will be less confusing if I now deal with the stations in turn and provide any amplification necessary to the information already provided.

TABLE 1

Station	Type	Studies	No.
Downton	Coal 4x500	a. Job descriptions of engineers	105
		b. Job descriptions of administrative staff	43
		c. Reorganizing of administrative duties	-
		d. Preparation of station manpower plan	-
Olliton Reach	Oil 4x500	a. Job descriptions of engineers	110
		b. Restructuring studies	-
		c. Preparation of new job descriptions	20
Fossil Strand	Nuc. 2x660 6x94	a. Various 'new post' job descriptions	30
		b. Administration job descriptions	50
		c. Restructuring administration & new posts	20
		d. Analysis of all engineers work for Tribunal Award	150
		e. Study of development department including attitude survey	18
		f. Study of electrical maintenance branch including attitudes	117
		g. Job descriptions for mechanical maintenance engineers	27
		h. Job descriptions for instrument maintenance engineers	34
		i. Study of reactor fuelling	15
		j. Duties of computer engineers	6
		k. General job descriptions for reactor physics; health physics; operations	40
Ash Haven	Coal 3x500 6x100	a. Attitude survey comprising a cross section of all the station staff excepting admin.	186
		b. Personnel Handbook	-
T.V.A. H.Q.		Discussions on working systems in T.V.A.; e.g. construction of power stations, centralized maintenance, training.	8
Sequoyah	Nuc. 2x1150	Over-view of station organization. Departmental working patterns. Duties of staff.	8
Bull Run	Coal 1x900	Study of station organization. Working patterns and workflow procedures. The handling of planning, overtime, unplanned outages, the use of hired labour.	12
Marshall	Coal 2x350	Organization of the Duke Power Company. Construction and maintenance of the power station. Station working procedures including plant modifications and major outages.	10
R.H.Q.		Reorganization of headquarters departments. Writing new job descriptions for branch heads.	20
		Approximate total number of data gathering interviews	1,129

COMPONENT STUDIES OF THE RESEARCH

Downton Power Station studies The job descriptions were provided as a part of C.E.G.B. policy but were considered to be of value by the station manager for the purpose of making adjustments to the organization to meet the changing plant needs.

The administrative department restructuring was to enable the administrative officer to achieve several targets namely:-

1. To delegate a number of routine tasks to section heads so as to provide sufficient time to tackle currently neglected work.

2. To provide additional services at the station.

3. To more closely match the tasks of administration staff to the new grading classification.

4. To create suitable posts for newcomers with a low skill and high learning content.

5. To replan jobs so as to provide adequate cover for staff absences. (e.g. 100% cover for telephonists; 30% cover for the administration officer.)

The preparation of the station manpower plan provided useful information about sickness, absenteeism and turnover rates. From numerous discussions with staff members, certain aspects of the working patterns of industrial staff were obtained and certain organizational procedures (e.g. the planning system) were analysed.

The changes at Olliton Reach In addition to the studies which were outlined in Chapter 2 valuable information was obtained at this station about the working patterns associated with the commissioning of a new station, and the gradual building up of the organizational structure. Information about the social background of the area and the way in which it affected the attitudes of many of the workforce was studied. The inter-play between operations and maintenance was another special topic for investigation at this station.

<u>The Fossil Strand saga</u> The studies at this station continued intermittently over the full life of this research and during the tenure of office of four station managers (one temporary). During this period the changing organizational requirements in relation to the new 'B' station were studied and much of the work at this location was in relation to the staff requirements as commissioning progressed.

When the station manager perceived the need for additional staff he would normally briefly outline the requirements for the new job and leave it to me to translate these expectations into a coherent job description together with the associated advertisements. A rather different problem arose with the administration department which found itself faced with an ever-growing workload and a need to re-organize. My involvement was to discuss the workload with various individuals, consider the overall pattern and write appropriate job descriptions for the new posts. The increasing use of computers in administration made it advisable to include a separate section, which existed for three years before being disbanded. The re-organization was only partially successful because of a tendency to promote existing postholders to new senior posts which were sometimes beyond their competence.

The size and complexity of the organization at Fossil Strand made it difficult for management to exercise effective control and attempts were made to alleviate the situation by the preparation of organizational charts, the writing of job descriptions, the preparation of a manpower plan, and a series of group analyses. One of these was a study of the development department which existed almost as a separate entity on the site. The other was a substantial attitude survey of the electrical maintenance branch which was planned to be a comprehensive picture of a complete station function. Job descriptions were prepared for all the posts within the branch and a semi-structured series of interviews were carried out to determine attitudes towards the station, management, communications and the type of work. All the engineers and foremen were interviewed together with approximately one quarter of the industrial staff. An additional part of this study was the analysis of industrial staff attitudes to typical tasks and for this purpose one quarter of the total branch workload was analysed.

The Ash Haven survey The background to the survey has already been described as has the method of conducting the interviews. In setting up the study the intention was to aim for a 15% sample rate and to sub-divide the staff into groups so that the opinions and work of all sections were analysed. Management required special emphasis on those groups having high turnover rates and they requested that exit interviews be held during the period of the research.

At the time of the study there were 196 engineering staff (N.J.B.)* and 895 industrial staff (N.J.I.C.)* on the site. There were also about 60 clerical staff (N.J.C.)* but these were not to be interviewed. Contracting staff engaged in diverse projects worked on the site, the average number being about 500.

The N.J.B. staff were divided into groups some of which only contained a few members. However, I decided to have a minimum of two interviews from any group to avoid single unrepresentative opinions being expressed. The resulting sample list is shown in Table 2 and resulted in 26% average sample. For the N.J.I.C. staff the selected groups and samples are shown in Table 3. It can be seen that high sample rates were used for the mechanical, electrical and instrument craftsmen in accordance with the management's wishes. The final sample of 14% was increased by exit interviews to a final figure of 15%.

Individuals for interview were selected from staff lists by the use of random number tables. All the names in a group were numbered consecutively e.g. from 1 to 21 and the sample size was determined e.g. 6. The first six different numbers in the table lying between 1 and 21 were then marked on the list. A further two numbers were noted as the first and second reserves. All the staff on the station were aware of the survey since management had discussed the problem and obtained the agreement of the works committee representatives before my involvement. Each person selected was sent a letter

* N.J.B. = National Joint Board)
N.J.I.C. = National Joint Industrial Council) For details refer to page 178
N.J.C. = National Joint Council)

N.J.B. Staff Sample

Staff Group	Staff Total	Sample Taken	%
Departmental Heads	5	2	40
Planning and Work Study	24	5	21
'A' Stn. S.C.E.'s and A.S.C.'s	10	3	30
'A' Stn. Ops. Shift Engrs.	21	5	24
'B' Stn. S.C.E.'s and A.S.C.'s	11	3	27
'B' Stn. Ops. Shift Engrs.	13	3	23
Test and Efficiency	5	2	40
Chemists	10	3	30
Maintenance Engrs. 'B' Stn.	19	4	21
Maintenance Engrs. 'A' Stn.	12	3	25
No. 9 Commissioning Team	16	4	25
Development & Projects	26	5	19
Development 'A' Stn.	3	2	67
Shift Maintenance Engineers	11	3	27
Site Services & Technical Audit	10	3	30
Totals	196	50	26

Plus any leavers during period.

TABLE 2 ASH HAVEN N.J.B SURVEY SAMPLE

Staff Group	Staff Total	Sample Taken	%
Ops. Foremen	20	3	15
'A' Stn. U.O.'s and A.U.O.'s	60	6	10
'B' Stn. U.O.'s and A.U.O's	40	4	10
'A' Stn. Ops. A.P.A.'s	56	5	9
'B' Stn. Ops. A.P.A.'s	70	7	10
Coal & Ash Plant Foremen	10	2	20
Conveyor Ops; Plant Drivers etc.	72	7	10
A.P.A./Drivers Coal Plant	26	2	8
Mech. Maint. Foremen	20	3	15
'A' Stn. Mechanical Fitters	27	5	19
'B' Stn. Mechanical Fitters	66	12	18
Electrical Foremen	13	2	15
Elect. Fitters 'A' Stn.	21	6	29
Elect. Fitters 'B' Stn.	31	7	23
Instrument Foremen	8	2	25
Inst. Mechanics 'A' Stn.	19	5	26
Inst. Mechanics 'B' Stn.	28	8	29
Semi skilled:- Crane Dr. Mates, oilers etc.	78	12	15
Site Services Foremen	12	2	17
Labourers, Drivers, Cleaners etc.	90	9	10
Gatekeepers	13	2	15
Welders, Riggers, Laggers, Mech. Fitters (S.S.)	50	7	14
Boiler Cleaners	24	2	8
Carpenters, Bricklayers, Painters, Plumbers	14	2	14
Cooks, Canteen Attendants etc.	9	2	22
Stores N.J.I.C. Staff	23	2	9
Messengers, Safety & Training Foremen	4	0	0
Work Study Assistants	14	2	14
Totals	918	128	14

TABLE 3 ASH HAVEN N.J.I.C. SURVEY SAMPLE

N.J.I.C. STAFF SAMPLE NUMBERS

reminding him of the survey and its purpose and explaining how he had been chosen and asking for his co-operation. Also in the letter was an assurance that strict confidentiality would be observed with only the interviewee seeing a copy of the interview notes. The N.J.B. staff had an additional letter from their technical representative assuring them of his satisfaction with the arrangements for confidentiality. For this I prepared a matrix of figures (1 - 9) and letters (a - z) and allocated the codes in a random manner with the only key being a list of names annotated with the codes.

All the notes were typed against the code and the copies were sent by post to individuals. To preserve anonymity I addressed the envelopes and posted the letters thus ensuring that no-one else had access to names and codes. A letter of thanks was sent with the notes together with an envelope and a request that if any corrections or additions were necessary they should be made and the notes returned. About 25% were returned and in most cases the alterations were of a minor nature. Two asked that certain parts of the information should not be used in any report to the station since they would lead to investigations and upset a good working arrangement. All those who returned notes had corrected copies sent back.

The final stage in the administrative aspects of the study was to obtain clearance from the works committee representative of each group for the summarized data relating to that group. This was to provide an additional safeguard to that of my judgement in assessing whether anything identifiable or incriminating was included before the data were finally converted into a report for management.

Following that clearance the final report was prepared and initially only two copies were distributed, one to the station manager and one to the deputy. The station manager was displeased with the report and complained to the Regional Personnel Manager (my boss) who was not able to comment because he hadn't seen it. He was authorized by the station manager to see the report and subsequently considered it to be reasonable and only controversial or disparaging in one or two places. He thought it should have been distributed but did not apply pressure on the station manager to do so. The works committee representatives have asked for copies on several occasions (in accordance with the original undertaking) but the station manager steadfastly refuses to make the report available.

American power station studies These four visits to United States organizations were different from all the other studies undertaken because of the limited time available. In most cases the visits were of two days duration, but several times the discussions went well on into the evening.

At each of the three power stations visited the routine followed was much the same. I had a talk with the station manager and he outlined the organization and the general philosophy of its management. In the case of the Marshall plant the organization of the company was also outlined and organizational charts drawn. I then had discussions with all the departmental heads who made it their business to explain how their department worked, showed me the relevant parts of the plant (sometimes personally, sometimes by a subordinate) and introduced me to one or two members of their staff. Whenever possible data was provided e.g. copies of payroll and job descriptions. On average I spent half a day with each departmental head and his staff. Finally, I always ended my visit by a further meeting with the station manager. At these last meetings I sought to summarize and clarify information.

It is difficult to relate these brief two day meetings to the much lengthier studies in C.E.G.B. power stations. If complexity of organization were to be regarded as a function of staff numbers, then some of our power stations would require about fifteen days for an equivalent study. In practice it would be possible to find out the equivalent information in about five days given the same level of co-operation.

Analysing the data

In this section I shall not be concerned with the way in which the data are presented in this thesis. The general outline has already been discussed in Chapter 1 and more detailed information will be given, when appropriate, at the beginning of each chapter. There are, however, three areas which I wish to clarify before leaving this chapter. They all concerned the way in which the field studies data was first prepared for analysis in this research. Perhaps the title of this section should have been Analysis of Raw Data.

Correlation of attitude survey data The mass of data resulting from 186 interviews led me to the belief that a more structured series of interviews might have had advantages outweighing the greater freedom of the open but directed interviews which were actually conducted. For the purpose of the analysis the staff were divided into six groups as follows:-

N.J.B. staff (engineers and managers)
Foremen (all duties)
Operations N.J.I.C. staff
Mechanical maintenance N.J.I.C. staff
Electrical and instrument maintenance N.J.I.C. staff
Coal, services and other N.J.I.C. staff

The data were also divided into topics and these were grouped under six main headings as set out in Table 4. The sets of interview notes for each group of staff had to be transcribed, statement by statement, to the appropriate headings. With the sets of interview notes averaging between 1,000 and 1,500 words this correlation of 186 sets of interview notes into six sets of forty topics was the largest single task in the project.

The subsequent analysis was carried out in stages, the first being the preparation of group opinions on topics. To simplify this stage, data were tabulated whenever possible enabling statistical statements

TABLE 4

Subject	Topics
Work and working patterns	Comments about work Working conditions Standards of work Working patterns Shift work Shift manning Shift retiring age Stagger working pattern
State of plant and facilities	State of the plant Facilities Administration service Stores service Canteen
Systems	Planning systems Pay and Productivity Scheme Safety systems Training Job rotation
Management, Policy, Communications	Management staff changes Station Manager's style Policy Communications Separate stations
Pay & Human Aspects	Pay Team spirit Social aspects Leave and time off Overtime Travel Staff Status Discipline Use of contractors
Morale and staff turnover	Morale Industrial Relations Job satisfaction Post Holder's background Promotion prospects Staff leaving Alternative employment Staff grading system

TOPICS FOR ANALYSIS OF ASH HAVEN ATTITUDE SURVEY to be made on many topics. To amplify these statistics, comments which seemed particularly apt or made a significant point were used as quotations alongside the data in the text. Having analysed all the data for each of the six groups the next stage was to summarize the opinions of all the groups topic by topic. This produced the final attitude survey report but during this phase additional information, obtained from other sources, was added. e.g. Opinions on travel were supplemented by a survey of the distances travelled to work by members of staff. Data on supplementary benefits and housing costs were added to the discussion on pay. National staff turnover rates were obtained or calculated. The final result was the report for Ash Haven but it represents the subject matter for analysis in this thesis.

Use of Job Descriptions The several hundred job descriptions produced during the period of this research will be used in the next part of this thesis in two forms. A general picture of the work of individuals will be presented which sometimes represents an average relating to all the stations in the C.E.G.B. and at other times the same information is used to highlight differences in working practices at various locations. A number of statistical tables are presented and many of these contain averages for the percentages of time spent on different activities by groups of staff. Because a substantial number of staff have been analysed for the same function the validity of these figures is greater than would otherwise have been the case.

Activity analysis The field studies for this research were based on the formal organizational structure together with the staff divisions associated with the classification into engineering staff, administrative staff and industrial staff. This was inevitable in order to provide the services required by the locations. e.g. The re-organizing of the administration departments at Fossil Strand. This division was not entirely satisfactory for the purpose of the research since the staff classifications did not apply in overseas power stations and the organizational structure was changing within the C.E.G.B. power stations.

Variations in organizational structure are sometimes both desirable and inevitable giving the diverse cultures in which they operate as was pointed out by Handy in his book "Understanding Organizations" (1976). Some of the power stations studied were task orientated under Harrison's (1972) definitions of categories of organizational culture. Others were a combination of power and role orientation (probably better called rule orientated). To some extent they reflected the cultures of their countries of origin and in this research I will try to trace just how the Electricity Industries were influenced by events.

For the purpose of analysing the actual power station organizations the open system model of Miller and Rice (1967) has provided a starting point. The activity system has been related to the technology and to the timescale for the performance of tasks. This has then been used as the framework for dissecting the organizational structure. This process has allowed effective comparisons to be made between the various power station organizations studied. In a later chapter the chosen analytical system is related to the more usual systems for describing power station organizations in order to assess the levels of congruence.

PART 2

LIFE IN POWER STATIONS

The work carried out in power stations and how it is organized. The differences arising from the technology or the management style are also displayed. A systematic comparative analysis is carried out and conclusions are presented.

CHAPTER 4

TECHNICAL SYSTEMS OF POWER STATIONS

Introduction

This part of the thesis is primarily concerned with the work and activities carried out in power stations and to draw some conclusions. Before getting into this analysis it might be helpful for the reader to be given a description of the working conditions and the nature of the plant installed. Also some idea of how the plant operates and its general layout is provided in the form of diagrams.

General

Power stations are process plants converting one form of energy into another (or matter into energy at nuclear stations). The electricity must be produced as required and this fact is the basis of the advantage of large integrated power systems able to spread peaks in demand. From the earliest days, power stations have been big in relations to most other industrial plant. A modern 2000 MW station comprises one sizeable building and into it is packed the bulk of the machinery. Thus, these large but unostentatious buildings (yes, they are generally clad in corrugated iron) contain well over £M500 worth of plant (double for nuclear). Inside they are, not surprisingly, a mass of equipment with the essential items of any process industry being prominent. These are the pipes, pumps, valves, wires, switches and motors. Smaller buildings about the site house additional plant perhaps costing a further £M100.

On approaching a power station one is struck by the fact that the main building is bigger than it appeared from a distance. This is because it is also very high (usually in excess of 35 metres) which gives it proportions very different from most other factories. Outside the main building is the transmission switch yard which appears as a lattice of wires and aluminium frames. At coastal stations this yard is totally enclosed in another very large building to protect the equipment from the effects of salt spray. Other external buildings are the gas turbine house and the office block which also provides the main entrance to the complex. Generally, other free standing buildings or features exist particularly for coal-fired stations where the coal stockyard, conveyor system, precipitators and ash plant tend to clutter the station's surroundings. On inland stations the dominating structures are the cooling towers (massive empty concrete shells). The chimney, usually over 200 metres in height, is another major feature of all power stations except nuclear.

Inside the power station

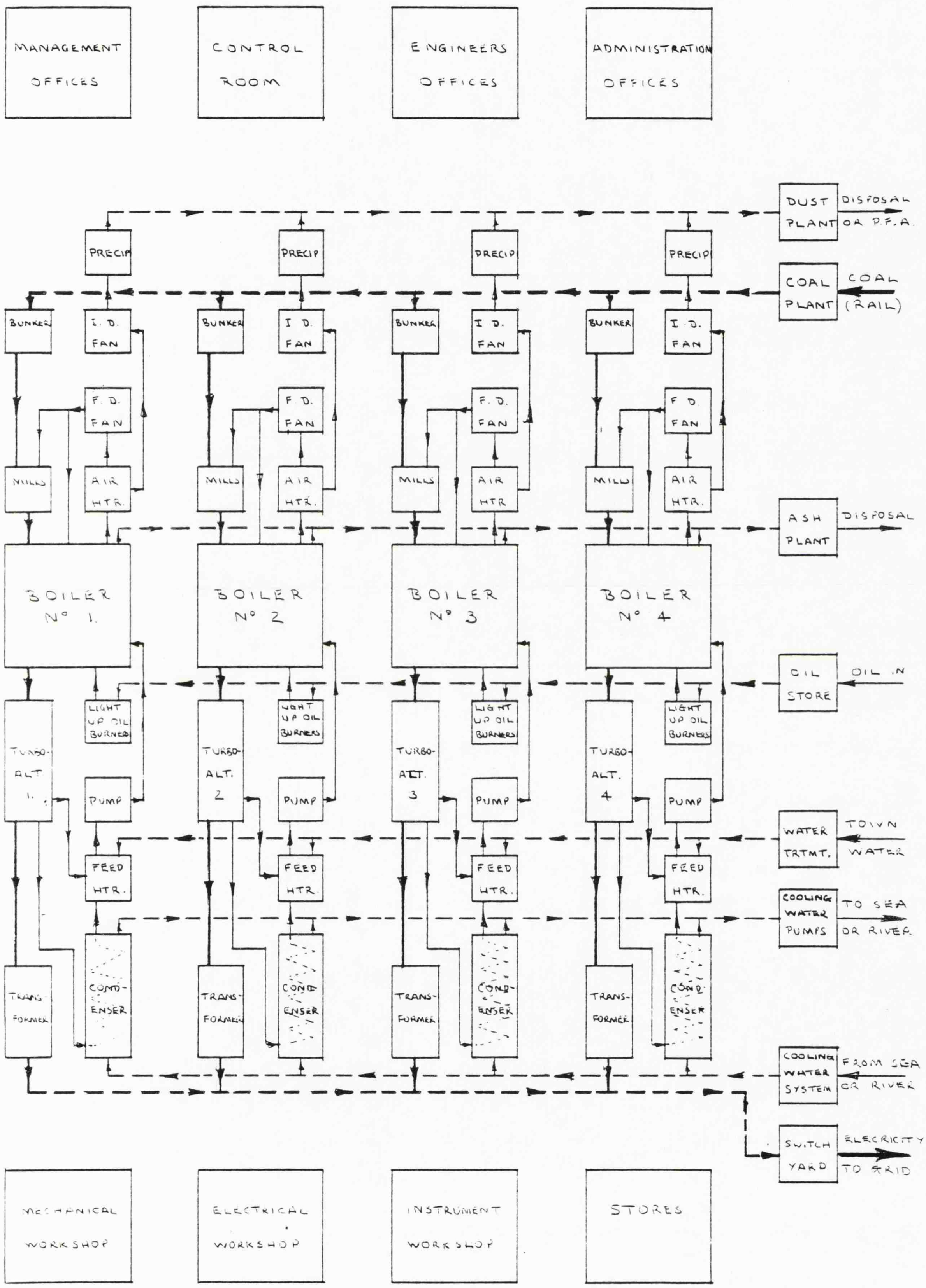
Nearing the main building entrance one is aware of the sound of the turbo-alternator and on entering, this is usually the most pervading noise. It is a penetrating sound more positive than a hum but at a pitch which is not unpleasant. It is accompanied by a feeling due to some vibration and the whole sensation adequately conveys a sense of the scale of the power being generated. It is quite probable that it has some psychological satisfying effect on the staff and at least one station manager expressed that view when he described the efforts he had made to avoid the station ever going "quiet" once the second unit had been commissioned.

One enters at the turbine hall level and four 500 MW sets in a row make a most impressive sight. These alone represent over £M200 of investment. Adjacent to the turbine hall is the control room which is a complete contrast to the rest of the plant and is generally quiet, carpeted and luxurious. Banks of dials, switches, lights and monitor screens are laid out in groups, one for each unit. Individuals sit at desks or walk around the dials noting readings. Seldom will one see anything happening as any switching or adjusting is the work of a moment and monitoring the effects is continuous. The more experienced a man is the less he appears to do. But I am wandering onto the next chapter, so I will leave the control room and get back to the main plant. In conventional stations the boilers run vertically from the basement to the roof but cannot be seen as a whole because of the intermediate floors. Burners are part way up the main chamber at the firing floor level (one of the few structurally solid floors).

Often switchgear, cabling and instrumentation are installed in the peripheral areas of the plant in separate bays where working conditions are clean and quiet. For the mechanical fitters most of the work is in the main area where noise levels are so high that speech is often not possible. Steam leaks are a major cause of noise so a well maintained station tends to be quieter. However, some makes of plant are inherently more noisy than others and the ever present compressors are a constant noise source. The basements are often very congested because much of the heavier plant is installed there. Care has to be taken to avoid injury from projections such as valve stems. At the upper levels most gangways and stairs are open grating providing access to plant items although staging is frequently required for maintenance or removal of plant items. Despite the substantial numbers of staff in U.K. power stations it is the exception to find someone working in an area and particularly so during shift hours. In the U.S. power stations one imagines it would be an event to meet another individual when out on the plant. Finally, it has to be pointed out that in nuclear stations a large part of the plant is inside the nuclear "fence" and work in that area involves changing, radioactive monitoring etc.

Some technical aspects

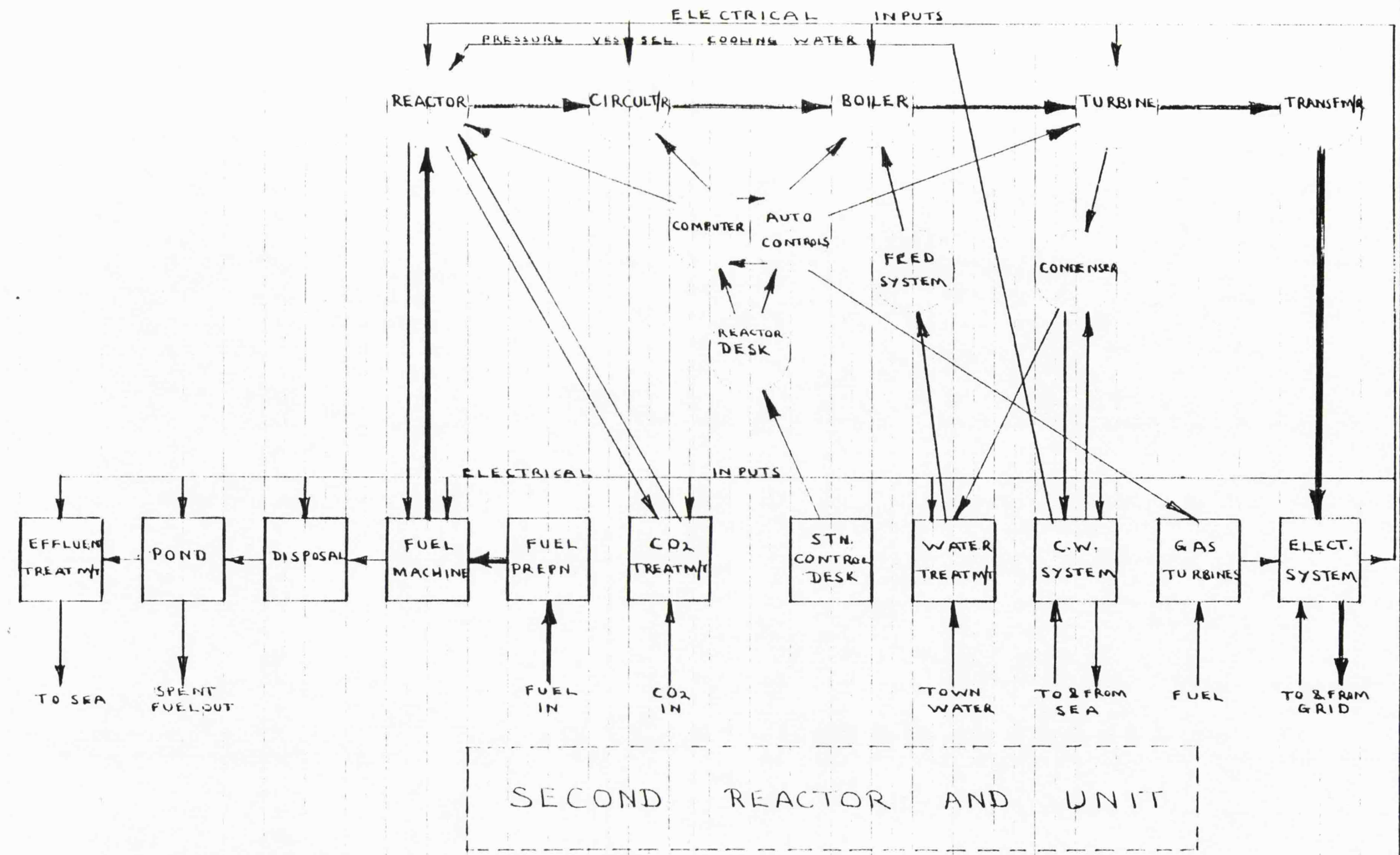
Inside the boiler the water is heated to steam in tubes comprising the boiler walls of the furnace area. This is the point where combustion occurs and heating is by radiation. The hot gases pass upwards through the steam superheater banks near the top of the main chamber and then pass across the top of the boiler and down the return leg progressively giving up more heat as they go, first to the water and then to the combustion air. The combustion gases then pass through dust extraction plants and into the flue via the induced draught fan. The ash extraction plant of coal-fired stations is substantial and removes about 200 tons per hour of gas entrained dust. Other major plant items associated with coal burning are the bunkers and the mills. The bunkers are near the top of the station and extend downwards towards the basement where the mills are situated. Coal is used at a rate approaching 1,000 tons per hour and it is as well to remember that only a little over one third of the heat produced is converted to electricity therefore the boilers of a 2000 MW power station produce about 6,000 MW of heat. The coal mills are large, noisy and cause a great deal of dirt in the basement. The heated pulverised coal and air mixture is blown to the burners under pressure and this a main cause of the dustiness of coal-fired stations. Any leaks or damage anywhere in the coal system enables the pulverised coal to blow into the building. The dust will then mix with any oil or water leaks to give caked dirt on plant items. So keeping a coal-fired station clean requires good operation, maintenance and housekeeping. By comprison, keeping oil or nuclear stations clean is mostly a matter of good housekeeping. Other major plant items on all stations are the water treatment plant, the feed water heat systems and the cooling water systems. Figure 1 shows the main plant items for a coal station and the materials flow relating to it. Figure 2 shows a similar diagram for a nuclear station. Finally, Figure 3 shows the feed water system which is the process fluid and the means by which the energy transfers are made between the units of plant. Many of the plant items in Figure 3 are duplicated for maintenance purposes and isolation and switch-over valves are required at each side of most items. Also, on a four unit station the system is quadrupled and these factors give rise to the mass of pipework, the joints, valves and pumps which are present. Most of the valves are motorised and all the pumps have motors some being very large (in excess of 4,000 HP). The other extensive water system is the cooling water and the quantities involved are enormous (about a quarter of a million cubic metres per hour). At coastal stations corrosion problems associated with this system are a major source of work.



MAIN PLANT ITEMS
FOUR UNIT COAL FIRED STATION

FIGURE 1.

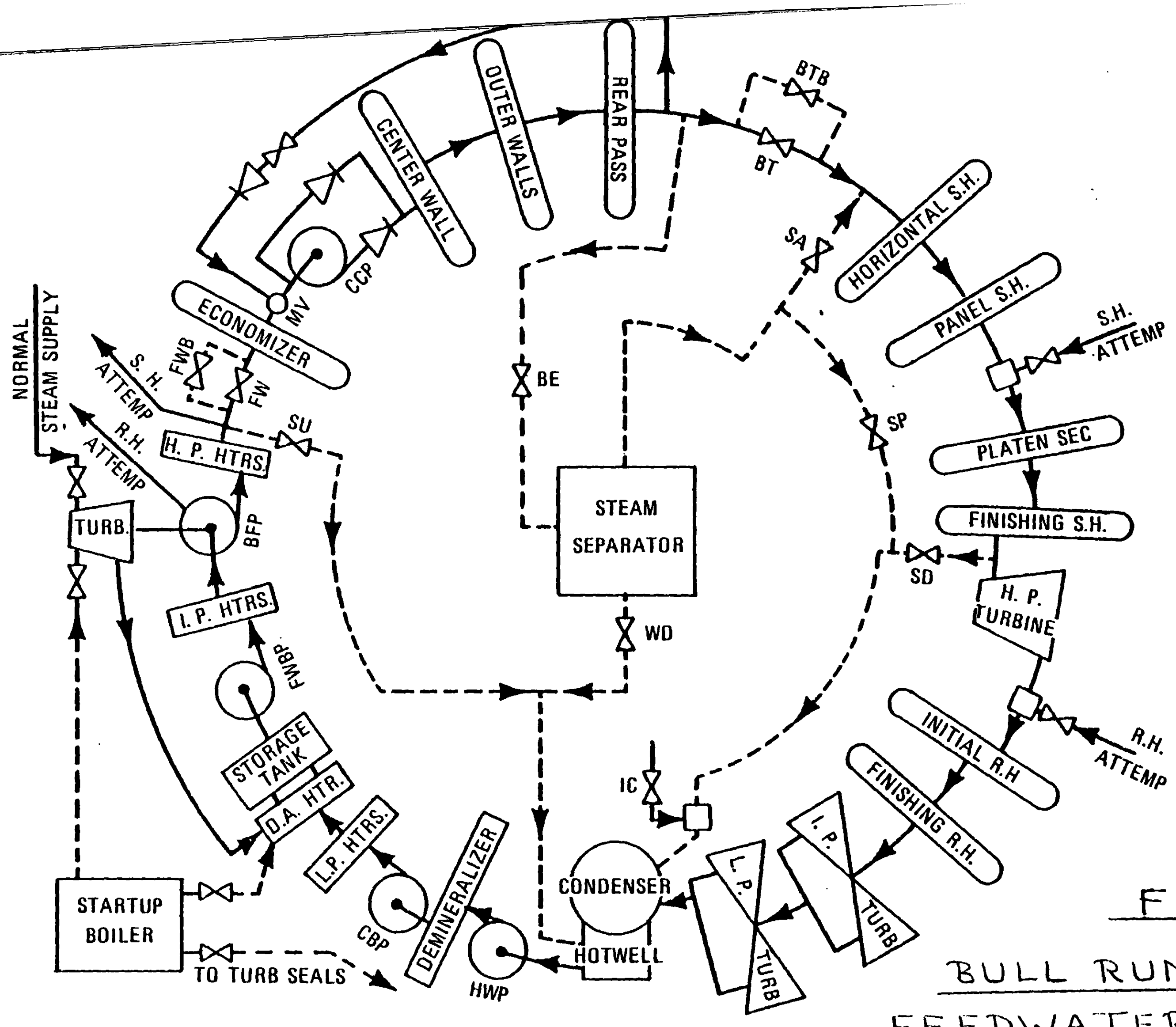
R. G. S. JOHNSTON 14.6.79.



TECHNICAL FLOW CHART
A. G. R. NUCLEAR STATION

FIGURE 2.

DRAWN
R. JOHNSTON
15·6·79



LEGEND

NORMAL FLOW ———
STARTUP FLOW - - -
BE – BOILER EXTRACTION VALVE
BFP – BOILER FEED PUMP
BT – BOILER THROTTLING VALVE
CBP – CONDENSATE BOOSTER PUMP
CCP – COMBINED CIRCULATION PUMP
FWBP – FEEDWATER BOOSTER PUMP
HWP – HOTWELL PUMP
IC – INJECTION SPRAY VALVE
SA – STEAM ADMISSION VALVE
SP – SPILLOVER VALVE
SD – STEAM DRAIN VALVE
WD – WATER DRAIN VALVE
SU – STARTUP VALVE
MV – MIXING VESSEL
FW – FEEDWATER VALVE

FIGURE 3

BULL RUN SIMPLIFIED
FEEDWATER FLOW DIAGRAM

COURTESY STATION MANAGER

The electrical equipment in power stations comprises motors of all sizes and maintenance work on these accounts for about half the electrical maintenance workload. The remainder is broadly divided between switchgear, batteries and lighting. Instrumentation is now much more extensive and includes computers. Much of the instrumentation is in clean areas of the plant but monitoring units are installed on many plant items.

All the stations but one in this research had unit plant in which each boiler or reactor serves one turbine (the exception was the magnox station where each reactor served three turbines). In the past, stations operated on the range system where boilers fed steam into a main which connected to all the turbines. As units became larger and steam conditions higher (pressure 168 bars; temperature 568^{o}C) this system was no longer practicable or economic.

Working conditions

In describing the power station environment I have attempted to outline the working conditions for many of the industrial staff. These vary greatly depending on the types of station, its state, situation and the job of the individual. In general, the most unpleasant working conditions are those of the plant attendants and mechanical maintenance fitters (and mates) at poorly maintained, coastal coal-fired stations. At these stations the electrical and instrument fitters are subjected to the same conditions but less frequently. The operations and maintenance engineers are also subjected to the noise but only when on the plant which is generally less than half the time. The rest of the staff are in offices most of the time and many administrative staff have probably never been inside the power station they serve.

At the nuclear stations, work on the disposal of spent radioactive fuel which is stored in ponds (like swimming pools) and work on contaminated equipment both require the wearing of special totally protective clothing (which is hot and uncomfortable) followed by the decontamination routine. The staff will usually work for a continuous period of several hours so as to minimise the total time on such work. In the U.S. nuclear stations (water moderated) these activities take place less often because 'on load' refuelling is not carried out.

CHAPTER 5

CORE GENERATING ACTIVITIES

Introduction

This introduction, which also serves the next three chapters, describes the system I will use for analysing the organization of power station work. It is based on the technology even though the most obvious choice would be an analysis based on the formal organizational structure since staff trees exist for all the stations studied. However, there were several examples of the same activity being assigned to a different part of the structure. Also the new C.E.G.B. proposals to amalgamate operations and maintenance into a new production department has to be borne in mind. For those reasons I decided against using the formal structure except as a secondary characteristic since it is still the easiest way of displaying the staff within the organization. The use of staff grades would be fine for the C.E.G.B. stations but no effective cross comparisons with overseas ones could be made.

Using the technology also aids the enquiry, because if different groups in separate stations perform the same function it is pertinent to ask why. I also considered it worthwhile classifying the work in terms of its relationship to the overall function of the organization. Before settling on this format I experimented with some methods for visually displaying the links between the formal structure and the informal, or actual, working patterns. Once such attempt was a three dimensional model using coloured strings to join the different components of the total organization and another made use of layers of transparent material each one showing a set of links between different parts of the organization. Such display methods may have proved satisfactory for small organizations, but in my study (a small power station) the result was a reasonable simulation of a "cats cradle" and provided very little enlightenment on the intricacies of the organization. As a result I used a classification based on that put forward by Miller and Rice in Systems of Organization (1967).

Classification of Systems of Activity

Miller and Rice termed all activities contributing to the furthering of the total process as operating activities. Those concerned with the procurement of resources or replenishment of the system were classed as maintenance and the remaining functions in most organizations were classed as regulatory. In relation to power stations, the system has some shortcomings because many activities would fall in at two of the classifications. The most important distinction for power station plant (and probably other process plant) is between those activities associated with the operating plant and those linked to the same plant when it is not operating. A further group of activities are indirectly associated with the plant and these coincide with Miller and Rice's regulatory activities. The timescale of continuous plant operation also had a significant effect on the activity grouping.

The activities have been grouped under three main headings:-

1. Core generating activities
2. Plant maintenance activities
3. Regulating activities

In the C.E.G.B. power stations a fourth set of activities is generally carried out and they are exclusively concerned with improving the plant either by correcting constructional defects or by making improvements to the original design.

The grouping of activities under this classification will be compared in Chapter 9 with the grouping associated with the three more usual classifications adopted by the industry. There is one more factor I would like to bring to the notice of the reader before listing the various activities to be considered under each of the headings.

Only two of the seven power stations studied could be classed as "steady state" and those were both American. The other American station was in the pre-commissioning state and the patterns of work described were those they would expect to adopt during the commissioning and thereafter. Responsibility for commissioning American power stations rests with the construction division who also take most of the responsibility for dealing with plant shortcomings. The practice in the C.E.G.B. has been to use the station staff suitably supplemented to cope with the additional commissioning workload. There is no point in time when a substantial part of the station workforce leaves the site and enables an observer to say "this organization is now structured for steady state operation". The result of this inter-weaving of two separate activities is that many of the jobs include tasks associated with post-commissioning problems together with tasks concerned with steady state operation. The final part of this preamble is to list the activities in each group.

Core Generating Activities The objective of a power station is to generate electricity and this is achieved by keeping the plant running and supplied with fuel. In the case of coal-fired stations a separate group of staff (the coal gang) perform the latter function but in the case of oil-fired and nuclear stations the supply of fuel to the plant is carried out by the operations staff. Operation of the plant includes certain maintenance activities such as lubrication. It is also the responsibility of operating staff to monitor the plant, change operating conditions and to take plant out of service ready for maintenance.

The other group of staff associated with the core generating activities are shift maintenance. As their name implies, they are carrying out maintenance activities but they have been included because the primary purpose of their maintenance is to keep the plant in operation. On nuclear stations the health physics provide an additional small group of staff whose services are required on a continuous basis. No work can be carried out in radioactive area without their services and so they come within this category.

Plant Maintenance Activities The jobs associated with the maintenance of the plant are mostly to be found within the maintenance departments. At coal-fired stations the usual practice is to continuously dump the ash into short-term storage bays which have to be emptied every few days. The emptying of these has been classed as a system maintenance function. One other group performing a maintenance function is the stores service but not necessarily the administrative aspects.

Regulatory Activities Some of these activities are forms of technical regulation and one or two aspects would come in the category of core generating activities. One of the groups is the chemistry branch which provides a technical monitoring service of certain plant conditions. On nuclear stations the reactor physics branch provides a similar service for the reactor conditions. The third technical monitoring group is the test and efficiency branch which measures physical conditions on all the conventional plant and equivalent parts of nuclear stations.

Station management, administration and planning groups all provide regulatory services. At C.E.G B. stations a group classed as site services perform a variety of functions from cleaning and maintaining the buildings to providing transport. They also perform such activities as safety and fire fighting. Although much of the work of this group could be classed as a form of maintenance, non of it is associated with the main plant system. At many of the stations studied these services were provided by outside contractors thus making them even more difficult to place within a power station organization. I have included them in the regulatory activities mainly because they are such a diverse group but their small size would hardly justify a special treatment.

Improvement Activities As already mentioned, these groups only exist in C.E G B. power stations. However, the same activities are frequently carried out by staff in other classifications and a rough distinction between the two groups would be in terms of size of project. At one station, projects costing less than £1,000 were maintenance responsibilities and those costing more went to the development department.

Shift Team Studies

I shall now return to the main purpose of this chapter which is to analyse the structure and work of those groups associated with core generating activities. It would have been convenient to have kept the same order of stations throughout this thesis but the investigations were different at each location and it will be more helpful to the reader if I first discuss those stations where a complete picture of the activities has been obtained. I will present the data for each station and follow this by making comparisons and drawing some conclusions in relation to these activities. Before presenting the evidence it might be helpful to the reader to have some idea of the numbers of staff involved in these groups.

Staffing Levels

The shift teams in power stations more or less coincide with the groups associated with core generating activities and data are obtainable about the numbers of staff on shift in certain power stations. This is displayed in Table 5 and shows the numbers engaged in shift maintenance together with the total number on shift. An interesting figure is the number of operational staff for each unit of plant (column 6). This is derived from the total operations shift team (column 5) by deducting 3 from the total and dividing the remainder by the number of units. The reason for deducting 3 is that there are invariably three members of staff (the shift charge engineer; his deputy; and the control room engineer) whose duties cover the whole station. The resulting figure has been further adjusted to correct for differences in shift rotas. On a 37½ hour week, 4½ persons are necessary to provide full cover. In the American stations this is closely achieved by having five persons for a single post or nine persons for a double post. The French stations operate a six cycle system which allows one and a bit crews to be on day relief. In the C E G B. power stations the engineers work a five cycle system but the industrial staff normally work a four cycle system which would require men to work longer than the standard week. As a result, men have time off within the shift

TABLE 5 POWER STATION SHIFT TEAMS

NO.	TYPE OF PLANT	NO. AND SIZE OF UNITS /	COUNTRY	OPS. SHIFT TEAM	AV. MEN/ UNIT	COAL AND ASH NO. MEN	COAL AND ASH SHIFTS	SHIFT MAINT.	TOTAL ON SHIFT
1	2	3	4	5	6	7	8	9	10
1	Coal	2 x 260	W Germany	17	7.0	-	-	8	25
2	Oil	2 x 160	Sweden	12	4.5	1	3	-	13
3	Oil	1 x 200	Italy	5	2.0	-	-	-	5
4	Coal	2 x 250	France	6	1.5	-	-	-	6
5	Oil	2 x 250	France	6	1.5	-	-	-	5
6	Nuclear	2 x 250	France	19	9.5	-	-	-	24
7	Oil	4 x 250	France	12	2.3	-	-	-	12
8	Coal	2 x 260 1 x 320	U.S.A.	17	4.7	-	-	-	17
9	Coal	4 x 200	U.S.A.	19	4.0	-	-	-	19
10	Coal	2 x 650	U.S.A.	12	4.5	-	-	-	10
11	Coal	9 x 200	U.S.A.	43	4.4	-	-	-	43
12	Coal	1 x 900	U.S.A. *	10	7.0	-	-	-	10
13	Nuclear	2 x 1200	U.S.A. *	9	3.0	-	-	5	14
14	Coal	2 x 350 2 x 650	U.S.A. *	14	2.8	-	-	-	14
15	Oil	4 x 500	U.K. *	39	7.2	-	-	51	90
16	Coal	4 x 500	U.K. *	35	6.4	20	2/3	26	81
17	Coal	6 x 100 3 x 500	U.K. *	69	5.9	20	3	27	116
18	Nuclear	2 x 291 2 x 660	U.K. *	79	15.9	-	-	18	97
19	Coal	2 x 550	U.K.	20	6.8	24	2	106	150
20	Coal	5 x 200	U.K.	27	3.8	40	2	130	197
21	Oil	4 x 500	U.K.	42	7.8	-	-	60	102
22	Nuclear	2 x 350	U.K.	35	4.0	-	-	11	46
23	Nuclear	2 x 166	U.K.	28	12.5	-	-	-	28

/ For stations 18 & 23 the numbers of reactors has been used.

* Stations visited in this Study

Averages (Column 6) =	) Oil Fired	3.9 men per unit
	) Coal Fired	4.5 men per unit
Operations Staff	) Nuclear	10.7 men per unit
Associated with	) France	3.7 men per unit
each unit	) U.S.A.	4.3 men per unit
	) U.K.	8.8 men per unit

rota and the staff figures in column 6 have been adjusted to correct for this factor. The overall averages shown in the table for different types of plant and for different countries only relate to the power stations in the table. Better comparative figures are obtained if one station of each type is used and these give the following results:-

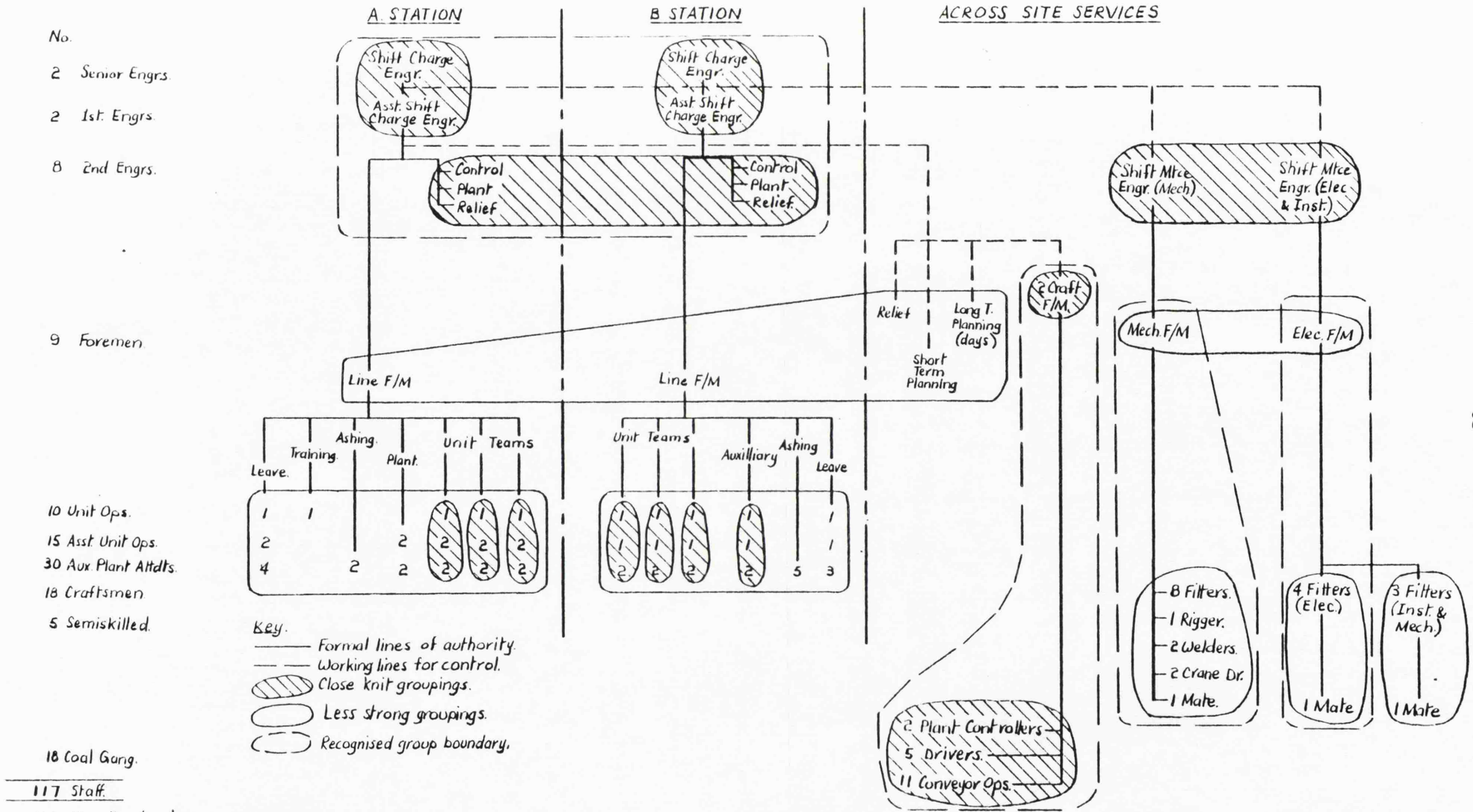
Size	of	average	unit	crew	in	French	power	stations	=	4.4 persons
"	"	"	"	"	"	American	"	"	=	3.9 "
"	"	"	"	"	"	C.E.G.B.	"	"	=	9.9 "

Some reasons for these discrepancies may emerge at the end of this chapter.

The Ash Haven Shift Team

The reader will recall that Ash Haven is a two station coal-fired site and in figure 4 it will be seen that the staff have been divided into groups for each station plus further groups serving the site. The group boundaries shown are divided into three types but in practice there are gradations between them. It would be correct to say that in addition to the boundaries shown, all the staff on shift at any one time during working hours would share a feeling of belonging to a community. This community feeling was less strong at Ash Haven than some of the other power stations studied because of the different shift rotas worked by the various groups. The operations and the maintenance engineers worked different rotas and the operations industrial staff worked different rotas from the maintenance industrial staff. The maintenance foremen worked the same rota as the industrial staff but the operations foremen were on yet another rota. The coal gang were different again giving a total of six different rotas for the staff shown in figure 4. I will deal with each of the groups in turn describing their jobs and inter-relationships.

The operations engineers In this group there are ten engineers forming three sub groups as shown. A shift charge engineer and an assistant is present on each of the stations and each pair stay together



ASH HAVEN SHIFT TEAM. FIGURE 4

but change stations every $2\frac{1}{2}$ years. The two shift charge engineers have responsibility for the management of their stations outside day working hours and work across the boundary between the shift and day staff. The engineers on week day morning duties always attend daily station meetings at which plant requirements and work programmes are discussed. During weekday afternoons the shift charge engineers (S.C.E.'s) apply pressure on the maintenance staff to complete work. During the latter part of the afternoon shift and during the night shift the S.C.E. will apply pressure to the operations staff to have items of plant isolated ready for maintenance the following morning.

Most S.C.E.'s reckon to spend about a third of their time walking around the plant for the dual purpose of checking on its state and maintaining informal contacts with the workforce. Perhaps another one third of their time is spent on administrative matters and dealing with minor industrial relations problems often concerned with work timing. Note:- The productivity scheme is discussed in Chapter 7, but it is the system by which work is allocated in C.E.G.B. power stations using job cards which set out what has to be done and how long it should take. Work done in the correct time earns credits which count towards the bonus scheme. Typical problems concern mis-timings, delays and snags with jobs etc. Much of the remaining time of S.C.E.'s is spent discussing plant problems (with shift maintenance engineers) and making the appropriate operating decisions particularly those requiring deviations from the planned work programme.

The assistant shift charge engineer (A.S.C.) provides overall supervision of the work in hand and acts as a relief to the S.C.E. Responsibility for the permit system is delegated to him. This system is devised to ensure safe working of the plant and comprises a card with an operations engineer's signature on it certifying that the plant items have been isolated. Most plant items when isolated are locked off and the permit to work card will contain a key which prevents the equipment from being switched on until the key is returned. On the 'B' station (the new one) the A.S.C. spends a considerable amount of time in the control room providing overall supervision and making technical decisions when required.

The other sub group of engineers comprise six second engineers (the A.S.C. is a first engineer; the S.C.E. is a senior engineer) who carry out three jobs on each of the two stations on a 15 week rota. Because they have no close allegiance to either station, they tend to form the 'across station' sub-group. Two of the sets of duties are as relief engineer during which time they will cover absence for the other four posts or the two A.S.C.'s posts. Thus these relatively junior engineers have to be capable of carrying out six different jobs on two stations whereas the more senior A.S.C. has to carry out two different jobs in relation to one station. Three of the four second engineer posts are mostly concerned with plant isolations and permits, the preparation of which occupy about three-quarters of the time. The physical isolation of plant items is normally carried out by industrial staff and subsequently may be checked by the foremen but it will generally be physically rechecked by the engineer. All electrical isolations are carried out by the engineers in accordance with set sequences. On completion the permits are written and signed. The remaining second engineer job is the 'A' station control room linking the station output to the grid and providing a communications link for the site. Work is uninteresting but the post has to be manned continuously. On the 'B' station the same controls are incorporated into the plant control room. The 'A' station plant has three small unit control rooms adjacent to the plant. The majority of these second engineers did not like the changing of stations every 15 weeks and would have preferred six months or longer in each station before the change.

<u>Operations Foremen</u> On each shift there are five operations foremen who carry out four different duties with one on relief. They work a four shift cycle different from that of the men which isolates them from both other operations groups. Two of the four duty foremen work in the planning office, one on long term planning and one on short. The other two foremen are on line duties one for each station. They change their jobs once every four months but the foreman on long term planning always comes in on days (irrespective of the shift) which means that the job rota provides a four months relief from shift about once every 2 years. One foreman surprised me during the interviews by

saying that he did not like the scheme but on enquiring further it turned out that his dislike was the dread of going back on shift at the end of four months. This innocent statement was probably the most damning indictment of shift work that I received during my interviews.

Probably the foremen's job in C.E.G.B. power stations is the one which was most altered by the productivity scheme. Under the scheme, foremen's duties included the planning of work in a works office which lead to a doubling of the foremen's posts. The short term planning foreman prepares a daily work schedule from the job card raised and allocates the work to various members of each shift taking into account the capabilities and the extent of training. Programmes are frequently revised to meet changing plant needs. Contact with the line foreman is maintained in order to monitor progress of jobs and to receive new jobs. Apart from the application of plant knowledge the work is entirely clerical and takes place in the works office.

The long term planning foreman (planning more than 3 weeks ahead) is one of three on duty at any time and several foremen considered the post to be a waste of time. The job is to build up programmes of work in the longer term in relation to major plant outages. The duties are entirely clerical. Works offices (manned by operations and maintenance staff) are often regarded as a useful information centre about job progress.

The duties of the two line foremen are those nearest to the traditional foreman's role. Each has responsibility for all the operational industrial staff on a station but a substantial proportion of these are divided up into autonomous work groups. As a result, the foreman is primarily concerned with the remaining staff associated with the auxiliary plant, and with cleaning, ashing etc. He will not have responsibility for allocating work since this will have been done on the job cards. He will spend a large part of the shift on the plant checking its state, monitoring the progress of work and ensuring that satisfactory standards are maintained. He will also raise job cards for work that needs to be done and feed these into the planning system.

He frequently facilitates work by organizing any equipment required which is not readily available. Certain of the isolations will be carried out by the foremen and others will be checked upon completion. The foremen have overall responsibility for ensuring that the plant training is carried out and have to give instruction in safety procedures. The maintenance of good industrial relations is another responsibility of the foremen most of whom attempt to get to know the industrial staff as individuals. However, this is made difficult by the different rotas worked. In practice the line foremen spend about three-quarters of their time on the plant applying pressure for urgent jobs and giving advice and assistance when required. The bulk of the remaining time is spent in the office dealing with the paperwork associated with the productivity scheme.

Operations Industrial Staff These are sub-divided into two groups one for each station. Interchanges are rare and not liked. Within these overall groups working teams called unit crews exist. Those on the 'B' station were permanent whereas those on the 'A' station were only unofficially permanent. Those members of the shift team with shorter periods of total service would normally not belong to shift crews and would carry out a range of subsidiary duties. There are three grades for the industrial staff and these are:-

1. A.P.A. (auxiliary plant attendant) are normally recruited from labourers or cleaners on the station, these duties being the expected means of entry for the unskilled staff.

2. A.U.O. (assistant unit operator) after three or four years as an A.P.A. a reasonably competent man would progress to this post.

3. U.O. (unit operator) after a further three or four years given competence and opportunity the A.U.O. will progress to the U.O grade.

Many of the A.P.A 's interviewed had previously held jobs outside the industry with pay levels much higher than any they could reasonably expect even as a foreman on shift. The reason given for taking the work was the job security involved but another factor might be the opportunity for "moonlighting" which was estimated at about 50% for the shift staff. During the first six months the A.P.A. will spend 90% of his time on cleaning duties and this leads to a high staff turnover rate. They then spend a year on cleaning together with ashing and dust removal all of which can be categorized as dirty and unpleasant work. During this period they are given training and gain experience with some of the auxiliary plant areas. Working conditions during the survey at Ash Haven plant were unpleasant and on the 'B' station the staff in the main plant area wear ear muffs all the time. Generally one task was assigned for the whole of a shift to an individual but a different task might be given for the next day. Most of the men would have preferred the same task for the whole of the shift cycle and this use to be done before the productivity scheme was introduced. For some jobs permanent crews existed (e.g. ashing) and the disbandment of these crews was considered by many staff to be a factor in the decline of station standards. The old ashing crews had ongoing responsibility for the state of the plant and were able to organize their own work. As a result they tended to get the unpleasant work done first leaving the easier jobs till later. Under the present system men tended to avoid the unpleasant parts of the job since it would no longer be their problem after the end of the shift. After some years on general duties an A.P.A. would be assigned to a unit crew.

The rest of the duties of the operations industrial staff are best treated within the framework of the unit crews. Those on the 'B' station had responsibility for one unit per crew with a spare crew having responsibility for the auxiliary plant but being available for the unit if necessary. The fifth crew would be off duty. The crews change their duties regularly. Before the productivity scheme the U.O. had responsibilities very akin to those of chargehands but the work of his team members is now assigned by the planning office.

Thus the autonomy and authority associated with unit crews has been reduced and I was given to understand that the sense of responsibility had also diminished commensurately. I was told that before the productivity scheme the crew members took a pride in the state and performance of their units. The unit operator spends most of the shift in the control room and therefore forms part of a close working group with the two other unit operators and the A.S.C. He is therefore a member of the control room team and the leader of the unit crew team. A good unit operator can sense the state of the plant and even detect variations between allegedly identical units. The ability to optimise combustion conditions and make allowances for such factors as the change in coal type come with experience. Most of the work is reading and interpreting instruments and making plant adjustments or checks. The job can be demanding and stressful particularly when changing the operating conditions on modern high merit plant such as on 'B' station. From time to time the U.O. will wish to inspect parts of the plants and the A.U.O. will then act as his relief.

The A.U.O. is the outside member of the crew with responsibility for carrying out checks and adjustments and particularly those on the turbine. Readings are taken on the plant and certain fault investigations will be carried out under the direction of the U.O.

The two A.P.A.'s associated with the unit split the job into the turbine plant and the boiler plant. Both will monitor plant behaviour and check operating conditions. They carry out tasks such as lubrication, venting pipes etc. The coal mills and burners have to be regularly checked as do the coal feeders. Such routine duties occupy about half the shift and a further one to two hours would normally be spent in carrying out isolations generally in conjunction with the A.U.O. This work often requires two people.

On the 'A' station the unit crews are a little different comprising one U.O., two A.U.O.'s and two A.P.A.'s. On this older plant each control room serves two adjacent units and the one U.O. monitors both sets of controls. However, for security, one of the A.U.O.'s carries out duties on the turbines and remains close to the control room so as to be available whenever conditions are changed. The other A.U.O. together with the two A.P A.'s carry out a similar range of duties on the plant to those of the 'B' station crews.

Because the 'A' station plant is less complicated, greater responsibility is delegated to the U.O. who normally receives instructions directly from the station control room about load changes and carries them out without notifying the A.S.C. Many of the subsidiary isolations are also accepted by the A.S.C. on the authority of the U.O., but in any case of doubt the engineer would check in the normal manner.

Shift Maintenance Staff The two engineers provide expertise in the mechanical and electrical plus instruments fields but also generally divide the work into one station each. Because the 'B' station is technically more advanced this is covered by the electrical and instrument engineer. The two engineers form a tight knit social group and would always join together for meal breaks. Because of the state of the plant they are normally kept busy dealing with technical problems which are usually investigated in conjunction with an operations engineer. Jointly, decisions are made which take into account the operational needs, the possibility of short-term solutions and the priority of work. The shift maintenance engineer (S.M.E.) will then discuss the work programme with the foreman who will inspect work in progress and probably re-allocate the fitters to meet the changing plant requirements.

The two foremen also form a group but they have stronger working and social links with the industrial staff (sharing meal breaks) than was the case with the operations staff. This is because the foremen and fitters work the same rota. The two foremen also generally cover one station each. The foremen and engineers both give technical advice and guidance when required and have to spend a considerable amount of time on administrative aspects such as work planning, productivity scheme timings etc. Under the productivity scheme planned work is provided for the whole of the shift even though it is expected that much of it will not be carried out due to plant defects arising. Making the changes, determining priorities and altering the programme are all tasks for the foremen. Because of the urgent nature of much of the work the foremen facilitate it by obtaining equipment or information relating to plant items. Much closer working contacts are maintained with the industrial staff by the foremen and fitters on shift than is the case on day work.

On each shift there is a team of electrical fitters and they cover both stations. In practice a greater proportion of their work is associated with the 'B' station. A similar situation exists for the instrument mechanics with the exception that they have no craft foremen associated with their work and tend to take more responsibilities for priority decisions. For both the electrical and instrument fitters defect work is much more demanding than routine maintenance and often involves diagnosing faults with the use of circuit diagrams and test equipment. The lack of diagrams and drawings often caused frustration to shift staff.

The mechanical fitters are divided into teams for each of the stations and tackle a much greater variety of work than the day staff. Jobs on shift tend to be shorter and more complete. A fitter with a pump defect on shift would expect to remove it, dismantle it, machine one or two components, reassemble and put back in service. On daywork the same job would be divided into three with one fitter removing and dismantling the pump; a machinist making parts (probably a day later) and different fitters reassembling and recommissioning the unit.

In addition to deviating from formal work procedures, shift staff tend to disregard some of the work demarcation practices. Foremen and engineers on shift are much more likely to be involved in physical work and mates, crane drivers and riggers on shift were expected to join in to complete the group workload. Examples were given of the way in which an initially unwilling newcomer to a team was coerced into exceeding his formal job boundaries by the other members of the team. There was a general acceptance that when a fair stint of work had been done the team could go on standby and would only turn out for breakdowns. This was an important reason why all the other shifts were preferred to the five weekday morning shifts when such unofficial practices were not possible.

The Coal Gang The coal plant is physically remote from the two main station buildings and the fact they work different rotas isn't so important. The two foremen in the shift team work the same rota as the men but form a separate social subgroup sharing mealbreaks. The rest of the coal gang formed a very tightly knit group with a strong sense of team loyalty. The coal gangs seemed to hold more social events outside work than the other shift groups and the two foremen normally joined in such occasions.

The foremen exercised a much higher level of authority over the workforce than was achieved by any other foremen on the site. They normally started work early (in their own time) so as to overlap the previous shift and find out the situation in relation to plant and progress. Such overlaps are common for all other shift foremen and engineers. The foremen share the duties of the two posts in an informal way, one job required taking charge of the coal control room, making decisions about the plant operation and contacting the main plant operations engineers if problems arose. The other foreman was concerned with work on the plant and at the beginning of the shift he would find out the planned work programme and allocate jobs to the members of the coal gang. He would then generally monitor progress of work, organize and supervise special tasks, investigate plant defects and organize maintenance work. He would expect to visit the whole of the plant at least once per shift and carry out various administrative duties.

The two most responsible jobs in the coal gang (apart from the foreman) were the plant controllers only one of whom was required to carry out the duties. The other was available for standby and they also covered a foreman's absences. (Remember that on a four shift rota all members of staff are off duty for one fifth of the time.) All the coal plant is remotely operated from the control room and its functioning can be observed by means of television cameras.

Part of the policy for the coal gangs was to allocate some of the less physically demanding jobs to the older men. Each shift had five drivers covering a variety of plant items such as the bucket wheel reclaimer, bulldozers and locomotive. Two of the older members of the twelve conveyor operators in a shift team carried out coal sampling duties which required the taking of coal samples and their preparation by systematically bulking, dividing and drying until a small bottle full of powder contains a representative sample of all the coal received during a shift. The remaining conveyor operators were split into four groups, one covering the 'A' station bunkers, one the 'B' station bunkers, one the conveyors and the fourth on general duties. These duties were changed on a monthly rotation basis. For all of these duties the effects of climatic changes were considerable. In the summer, work (especially the bunker trimming) could be extremely hot and very dusty and in winter the same areas were fairly cold. The coal conveyors were particularly cold and uncomfortable in winter being elevated corrugated iron tunnels sloping at an angle of 15^{o}. Much of the coal used is fine anthracite which can be wet and "pudding like" and tends to block hoppers, chutes and bunkers. These blockages result in spillages and make the work so dusty in summer that it has to be carried out wearing masks. The conveyor operators always worked in pairs partly for safety reasons. E.g. if a man gets caught up in a moving conveyor his work mate can instantly switch it off. In addition to the general clearing up of spillage on the whole plant each shift was expected to thoroughly clean their own plant area. Each of the four shift crews had special responsibility for the cleanliness of a quarter of the total coal plant.

The foremen explained that the productivity scheme was "fiddled" for the coal gang with the work order cards being mistimed and the returns being made up by the foremen. As a result they got twenty nominal hours of work out of each 8 hour shift. The most interesting point about the coal gangs was that their morale and loyalty to the station was significantly higher than that of any other section of the workforce and their sense of community was very strong. The foremen thought well of the men and said there was very little scrounging and that they would turn out for an urgent job even at the end of a shift. The men considered the foremen to be fair, tough but allowing very little easing up outside normal break periods. Their main complaint was the need to work night shifts which they considered to be due to the inadequacies of the plant and particularly to the 'B' station bunker design. These bunkers were intended to hold a 12 hour supply but due to poor coal flow characteristics the amount of "live" coal in the bunker is limited to a very small proportion of their total capacity therefore they need continuous topping up. The men also considered that many parts of the coal plant would be rapidly improved if some of the engineers responsible had to carry out duties in the present conditions. An interesting minor point was that a few mechanical maintenance fitters were assigned to the coal plant and had become integrated into the coal gangs because they enjoyed the friendly atmosphere even though the work they were carrying out was by no means the most satisfying on the site.

I shall summarize some of the more important points at the end of this chapter but first I will present information about the work of similar groups in the other stations studied and particularly those aspects which differ from the work at Ash Haven.

Fossil Strand Shift Team

Fossil Strand, in common with other nuclear stations, is operated to more stringent requirements than is the case for conventional plant. These requirements derive from three main factors which are:-

1. The need for certain plant to be operationally available at all times (e.g. circulators) to avoid situations which could cause nuclear pollution.

2. The need to maximise the operation of the nuclear plant with its low unit production costs.

3. The technically more advanced nature of the control and monitoring equipment.

In the C.E.G.B. nuclear stations this has led to a policy of using engineers to control the reactors rather than industrial staff (unit operators in conventional stations). The situation is different in the United States as will be described later although nuclear operators require an additional Federal licence. This resulted in the conventional station jobs of A.U.O. and A.P.A. being carried out by plant operators and plant attendants with pay rates equivalent to U.O. and A.U.O. Another associated change is the creation of chargehands to lead the small team responsible for operating the pile cap charge machines. With the creation of the productivity scheme the Board disbanded the post of chargehand but the small three man crew would hardly justify a non working foreman. Thus one change at the unit operator level has made it necessary for the Board to upgrade all the other posts in the hierarchy, and to disguise the fact changed the names, even though many of the duties are identical in nuclear and conventional stations.

The division of the shift team into A, B and site services groups was broadly similar to that at Ash Haven because Fossil Strand is a two station site. The strength of community spirit was greatly strengthened at this station by the use of fewer rotas. All the engineers and foremen (both operations and maintenance) were on the same five cycle rota and the rest of the industrial staff were on a common four cycle rota. The operations engineers did not normally change from one station to the other and the foremen did not alternate their line duties with those of the works office on a regular basis. There were six maintenance foremen and six engineers for each post and it was left to those individuals to arrange rotas and ensure continuous cover. They had to think back over six years before they could remember an occasion when a double mishap had prevented full cover from being provided. On each shift there were four maintenance engineers one for mechanical, electrical and instrument maintenance together with a computer engineer. There were only three foremen on each shift one responsible for the mechanical maintenance staff, one for the electrical and instrument maintenance staff, one for those working on the nuclear fuel route. (On a nuclear power station the reactors and the nuclear fuel route are inside the "nuclear fence" and it takes about 1½ hours to undergo the entry and exit checks.)

There were some interesting differences in attitude between the operating teams responsible for the 'A' and 'B' stations. On the 'A' station the S.C.E. was an authoritarian figure keeping a distance between himself and the rest of the team. They jealously guarded their position by providing cover whenever possible for absences rather than permitting upgrading of A.S.C.'s. On the 'B' station the S.C.E. worked closely with the other engineers who together formed a close knit team and one reason was the complexity of the 'B' station system and the sense of financial responsibility they felt towards its operation. This manifest itself in the varying degrees of unwillingness to release plant for maintenance which subsequently caused a great deal of frustration to the day maintenance engineers. (Some told me that it was necessary to pick the right shift team in order to get a permit to carry out work). This apprehension related to the computer control of the plant and the complex system of safety interlocks which might cause the reactor to trip as a result of cascade inter-actions following the closing of e.g. a minor piece of plant. The loss of output from such a reactor trip would cost in the order of £K250. This was also the reason why many of the control plant adjustments on maintenance were carried out by engineers as the accidental closing of a relay when testing plant could also lead to a trip. The 'A' station plant was much simpler and a possibility of an unintentional plant trip was much less even though the penalty for such a mistake could be in excess of £K100. The general allocation of duties for the operations engineers was similar to that at a conventional station with much of the engineer's time being concerned with plant isolations and the writing of permits. The role of operations foreman was far less significant than that of their conventional station equivalent due to the more skilled work being carried out by engineers.

The differences between shift maintenance work and daywork were similar to those at Ash Haven. A difference being that whereas the Ash Haven plant was dirty and badly maintained, the Fossil Strand plant was both cleaner and better maintained. Much closer co-operation existed between the maintenance and operations staff which enabled many jobs of lesser importance to be carried out for the operations engineers almost on a "personal favour" basis. All the maintenance engineers agreed that the feeling of being a part of the shift team was much stronger than the sense of loyalty to their base maintenance branches. All considered their role was that of being present to keep the plant operating for as long as possible.

A similar attitude existed towards work with all grades of staff subscribing to the work ethic that they should do everything physically possible to keep the plant operating and be prepared to a reasonable stint of routine work. One foreman said he preferred the type of fitter who would very hard when necessary and would otherwise do the minimum of work and spend the rest of the time in the canteen. A general view of those on shift was that the work output was about the same as that for day staff (namely about 4 hours per day). The commitment to keep the plants operating was illustrated by an example given to me. Normally over the Christmas holiday period it is understood that the shift staff will not be required to do any work which is not absolutely necessary for the continuing operation of the plant. Usually the level of breakdown work would naturally increase over the period because day staff are absent for nearly a week. This understanding also allows the shift teams to operate with the minimum permissible numbers enabling the maximum number to be off duty. One job invariably avoided is the refuelling of reactors. Because the refuelling programme was so far behind schedule, the operations superintendent had to explain to the shift crews that refuelling would regrettably be necessary if a reactor shutdown was to be avoided in about 2 months time. In the event, the shift crew carried out more refuelling during the Christmas week than in any other week of the year. It also transpired that they had organized themselves so as to enable each group in the team to have an extended meal break over the Christmas spell. The behaviour appeared to bear out the contention that performance levels and commitment to the job were possible which were greatly in excess of those normally obtained.

Olliton Reach Shift Team

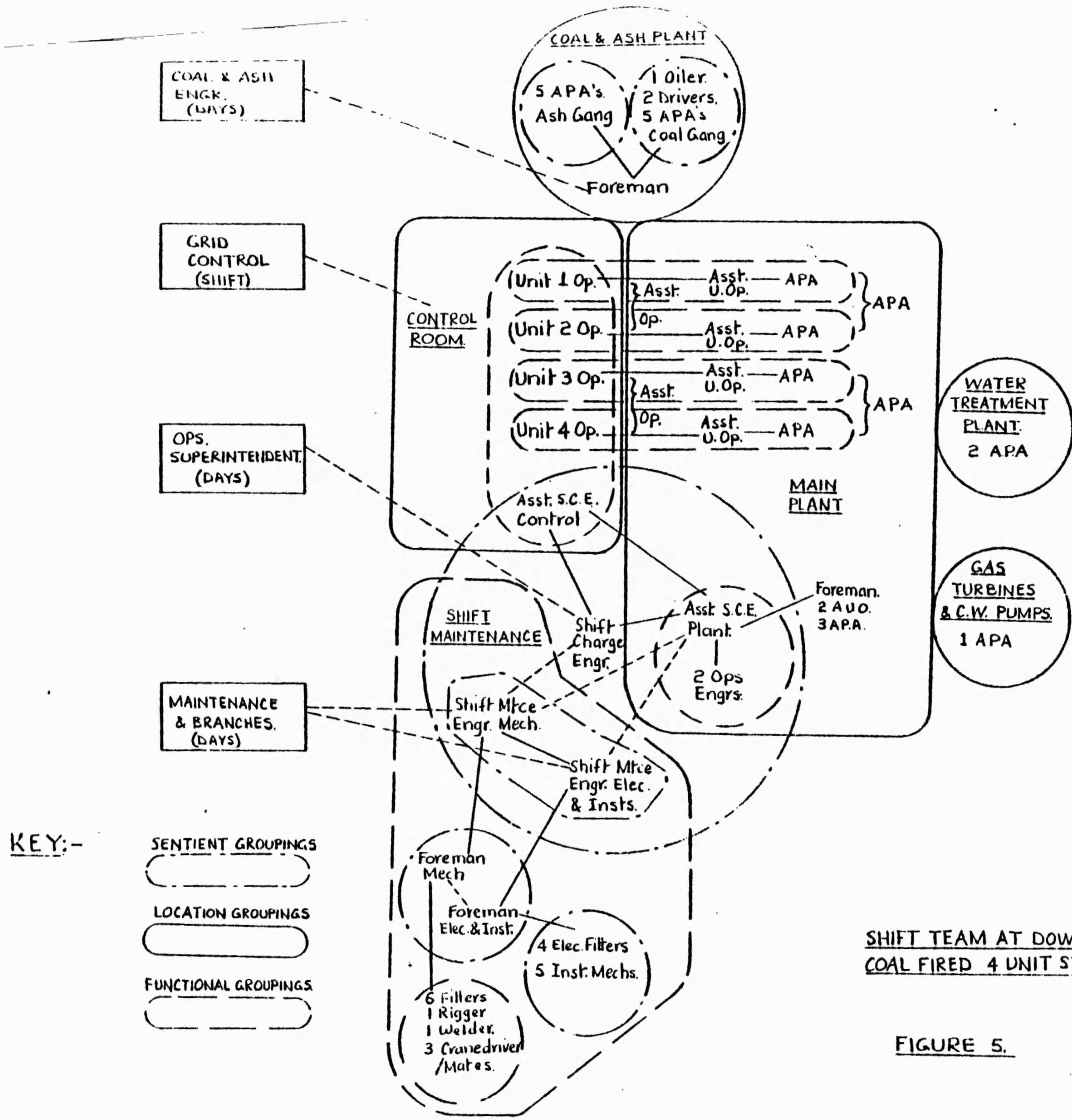
There was one interesting difference in shift working practices at this station which I wish to comment upon. This was the practice of carrying out the bulk of maintenance on shift. Operation shift teams were similar to those in other stations. The maintenance superintendent took the view that the breakdown maintenance workload would extend to absorb the whole of the shift maintenance effort if it were allowed. With four-fifths of the maintenance staff working on shift the programmed work had to be given priority. Thus the shift maintenance engineers were officially encouraged to refuse to carry out breakdown maintenance unless an emergency card was prepared. Half the shift maintenance engineers endorsed this attitude and the remainder found it very difficult to be helpful to the operations engineers and still subsequently justify their actions to the maintenance superintendent. This official lack of co-operation manifest itself in some hardening of attitudes and formalizing of communications. An example was given of the return of a pump to service. The operations engineer recorded in the shift log that it was not possible to test the pump because a permit was still in operation. Day maintenance read the log and left a message for the night shift who subsequently cleared the permit and put it into the planning system. The following night the cleared permit was returned to the operations staff who then discovered that an electrical permit was also outstanding and so it was still not possible to test the pump. A similar two day procedure was carried through for the second permit. The formal system therefore kept the pump out of service for four days and yet the engineers clearing the permits were working on the same shift as the operations engineers. The close co-operation between operations and maintenance engineers at Ash Haven and Fossil Strand would have ensured that the delays were dealt with in a matter of minutes.

An interesting insight into team loyalty was given at this station which went as follows:- during the pre-commissioning period the various grades of operations engineers were recruited and divided into five teams each of which was assigned one fifth of the plant with the requirement that they became thoroughly familiar with it, devised the operating procedures and wrote the operating manuals. (These are a massive set of books covering the whole of the plant). The teams carried out their work for about a year and was then deliberately dismantled to create new teams providing composite skills covering the whole of the plant. Because of the strong group ties which had been built up this action led to protests. However, after about six months of plant operation the operations superintendent decided to carry out further adjustments to the teams to get a better balance between the strength and weaknesses of individuals. He experienced a similar level of protest to the breaking of group ties even after so short a period.

One other useful piece of research carried out at Olliton was the amount of effort necessary to perform the isolations. It was found that the work would occupy one engineer continuously for 24 hours a day. After allowing for work peaks at outage times this meant that one engineer would always be deployed full-time with upto three additional engineers working part-time. The work was considered to be routine and not demanding and suitable for someone trained to a lower level than that of C.E.G.B. engineers. It was pointed out that a typical isolation would take from one to four hours, a strict sequence of operations had to be observed.

Downton Shift Team

Of those C.E.G.B. stations studied this one most nearly conformed to what might be termed a standard C.E.G.B. modern station. This is because, unlike Olliton, the bulk of maintenance work was carried out on days. For this reason I have prepared a diagram (figure 5) showing the main groupings and links for a typical shift team. Some of the less strong links are not shown such as between the coal and ash



SHIFT TEAM AT DOWNTON 2,000 Mw
COAL FIRED 4 UNIT STATION.

FIGURE 5.

foremen and the assistant S C.E.'s. Also informal links existed between the maintenance and operations foremen. One of the two engineers on shift maintenance covered mechanical engineering and the other dealt with electrical and instrument. At this station the more usual practice of having a first engineer and a second engineer was followed with the mechanical engineer always being the nominal first. I was assured that the prospects of becoming a first engineer were equal for both types.

At this station it was pointed out that at certain times of the year the priorities of operations and maintenance work would be reversed (during summer major outages). On these occasions the shift maintenance crew might be given routine work of such high priority that it was not to be stopped for breakdowns excepting for emergency requirements. The station manager said that this system sometimes failed due to the high level of co-operation existing between the operations and shift maintenance staff. He welcomed the close co-operation existing but said it did have this contra aspect. He thought that operations should always apply some pressure on the maintenance department to return plant into service and the reverse should take place to optimize the station's availability.

One of the problems tackled at this station was an attempt to overcome a difficulty associated with shift work. Shift staff always pass on work and problems to the team who relieve them. Day staff usually live with problems which face them again at 9 o'clock the following morning. There is therefore a natural tendency for shift staff to overlook problems. This is countered by the pressures from the other shift crews who would resent a slack team amongst them. Management has to take care that such resentment does not take the form of "tit for tat" as then the standards of the station would drop. At Downton efforts had been made to give the senior members of the shift staff ongoing responsibility for plant areas for functions. Each S.C E. had responsibility for a major plant area plus one minor plant area and a function.

Shift Teams in American Stations

Two of the three stations visited were operational and for the third the staff had been recruited and the structure existed. Staffing levels were low by C.E.G.B. standards and I was told they were basically staffed for steady state operation plus routine preventative and breakdown maintenance. During annual outages the workforce is supplemented and additional labour is hired for major breakdowns. Normally, no contract work is carried out except for very specialized services.

Bull Run Power Station The reader is reminded that this was a 900 MW single unit coal-fired station high on the American merit order. The shift team comprised a shift engineer plus an assistant together with a senior switchboard operator. The rest of the team (roughly equivalent to our industrial staff) comprised one unit operator, four assistant unit operators and two auxiliaries. In addition to this team there existed a coal gang who worked a seven day, two shift system. Also working a two shift system were a coal sampler and a chemist.

The shift engineer performed management and decision making functions and provided some cover for the other two posts. The assistant shift engineer had the primary responsibility for dealing with isolations and permits since he signed the "out of service" cards hung on valves, switches etc. which were their equivalent of our key. The switchboard operator spent his time in a control room monitoring plant output. The unit operator's task was very similar to that in our power stations and spent the shift at the unit controls. The four assistant unit operators cleaned and lubricated the plant and carried out isolations. The two auxiliaries provided general assistance, cleaning etc.

There was no shift maintenance at this station nor at the others. If urgent work was required out of normal hours then standby staff would be called in.

Sequoyah Nuclear Station This was a two unit P.W.R nuclear station with two 1,150 MW turbines. The shift crew envisaged to operate this plant comprised one shift engineer plus two assistant shift engineers. There were also two unit operators together with four assistants. Unit operators for nuclear reactors are required to have Federal reactor operator's certificates (given after passing appropriate examinations) and the shift engineer together with his assistants all required a senior reactor operator's certificate. The shift engineer had total responsibility for the plant in the same way as our S.C E.'s. He is authorised to call in maintenance staff if required. One of the assistant S.C.E.'s was responsible for work in the control room including any transmission switching and the other had responsibility for plant isolations and permits. The remaining duties were similar to those at Bull Run Power Station. On each shift there was one health physics technician per reactor whose duty was to monitor the plant, the staff and to check on the environment. He also had to monitor any equipment leaving the site and to check any laundry both before and after treatment.

The job specifications for all the operations staff had similar basic requirements which were for a high school qualification. The other requirement was to have held appropriate experience and training which generally included a period of years in the immediately subordinate post. For example, an operations superintendent had previously to have been a shift engineer for at least two or three years.

The management of this station thought it might be necessary to have a small maintenance shift team when the plant commenced operation and particularly for the initial period. A team comprising one foreman and between four and six craftsmen was envisaged. They would carry out breakdown maintenance at the direction of the shift engineer and otherwise perform a programme of preventative maintenance.

Marshall Steam Plant Shift Team This Duke Power Company station was coal-fired and comprises two units of 350 MW and two units of 650 MW.

The station has four shift teams each comprising a shift supervisor with an assistant. There are also four unit controllers together with four assistants and three plant assistants. The thirteen man team is allowed to operate with upto three members short although two of the day operations engineers were available for call in and others, including maintenance staff, could be brought in on standby. Coal handling was on two shifts for seven days each team comprising one foreman and six men. This group also dealt with the ash plant. The plant used three computers for logging and monitoring of read-outs which was designed to give the operator optimized performance information against which he could make his plant adjustments.

Core Generating Activities Analysis

In all the C.E.G.B. power stations studied these activities comprised operations, shift maintenance and fuel handling. In the American stations plant operation came within this category and so did fuel handling but to a lesser extent since two shift working was considered to be adequate. In the U S power stations shift maintenance was not considered to be a core generating activity. I will start the analysis by looking at the operations function.

Operating the plant The C.E.G.B. power stations visited had very much larger operations teams. In all the stations studied the shift engineer held a managerial role and this was far more extensive on the C.E.G.B. stations because he was drawn into policy making by his attendance at the daily planning meetings. Policy and planning meetings involving engineering staff from most groups and levels took place on all weekdays for a substantial part of the day. At Sequoyah Power Station I attended a daily meeting which lasted a little over 10 minutes and the items discussed all appeared to be non-routine in nature. I was told there was an additional weekly meeting at which policy was discussed. The S.C.E. in C.E.G.B. stations automatically has a greater managerial content in his work because of the substantial teams of men on shift (over 100 in some cases). The various man management functions occupied a significant proportion of these engineers time. From the analysis of the job descriptions of several S.C.E.'s it appeared that they spent rather less than a quarter of their time on each of management, technical work and administration. About a third of their time was spent on supervision. Their managerial decision making generally related to technical aspects and was often shared with the shift maintenance engineers. The operations superintendent at Bull Run said that the shift engineer was only required to notify him in the event of the set being shutdown. Occasionally shift engineers passed the responsibility back and an example was fortuitously given during my discussion with the operations superintendent. A shift engineer rang up saying he was having trouble with weed growth around the cooling water intake. The operations superintendent advised on the appropriate action and subsequently told me that the shift engineer was relatively inexperienced and in reality was passing responsibility for decision making back to the operations superintendent. A C.E.G.B. station manager told me that his staff were always entitled and expected to carry responsibility but that he would prefer them to hand it back if they were unsure rather than make faulty decisions. He said responsibility was often handed back in the guise of seeking advice.

The assistant shift engineer on all power stations had primary responsibility for the supervision of work in progress and for personally carrying out the more complicated aspects. He was also expected to give advice and make 'on the spot' decisions. At this point a diversion exists between the C.E.G.B. and American stations because the American assistant engineer has progressed through all the subordinate grades and had additional training. He is therefore more experienced than all those over whom he exercises authority. In the C E.G.B the foremen would be in this position but he has not been given the additional technical information. Thus the foreman's role is absorbed into the assistant engineer's job in American stations. Another common practice in C.E.G.B. stations is to have two A.S.C.'s, one on the plant and one in the control room. The American assistant carried out both duties and checked isolations before signing permits.

The unit operator post appears to be one with a common set of tasks in all power stations. He sits at the unit control and drives it. The only divergence is the C.E.G.B.'s nuclear stations where the unit operator is an engineer. However, by training and experience the American unit operators would probably be classed as engineers in C.E.G.B stations. For instance, the Sequoyah unit operators were required to have a fundamental knowledge of the principle of nuclear fission, reactors, thermo dynamics, principles of generation and operation of turbines. They were also expected to have a practical understanding of the way in which all items of plant functioned including the nuclear cycle. On the practical side they were expected to have an understanding of control systems and circuits including control theory and the effects of adjustments. Such an extensive theoretical background would not be expected in C.E.G.B. unit operators and would be regarded as the general requirements for all the operations engineers. On the American stations when the unit operator acquired a knowledge of health physics, safety rules and industrial relations procedures he would then meet the requirements for an assistant engineer. The shift engineer had the further qualifications of the ability to plan, direct and co-ordinate the work of personnel together with the ability to co-operate with all responsible parties associated with other aspects of plant operation. This absence of a bar to progress in American stations probably resulted in a higher calibre of staff within the lower grades of the organization, simplified staff supervision and avoided the triple checking of isolations etc. For example, the American job descriptions stated that the unit operator had responsibility for the work of the assistant unit operator who had the role of "advisor" to the most junior grade classed as student operator.

Comparing the operations roles in power stations it is seen that in the American stations the three basic functions were carried out by various members of the staff on a continuum of experience and training. These basic functions are:-

1. Doing work to the plant.
2. Applying engineering expertise to plant problems.
3. Using management ability for decision making.

A reasonably competent man could expect to carry out all three functions at various periods in his life. In the C.E.G.B. power stations these functions were divided and split with a similar continuum of experience upto unit operator level. A man could then progress to foreman level where supervision and decision making were applied in a reduced form but this level overlaps with junior engineers who provide technical expertise but cannot exercise the sort of authority required to implement technical decisions. The more senior levels then pick up the thread of management similar to that in American stations. Thus an organizational break seems to occur,with the provision of foreman at the top of the industrial progression tree and posts for junior engineers who are gaining experience in order to progress to the senior management level. Manifestations of this overlap were that two-thirds of the operations foremen's time in C.E.G.B power stations was spent in planning and work measurement and over half the junior engineer's time was spent in checking isolations before writing permits.

The differing shift patterns worked by various groups in C.E.G.B. shift teams were incomprehensible to American station managers. They regarded them as artificial hurdles put into the organizational system in order to make life more difficult. The generally expressed objection to common shift rotas by industrial staff was that they may have been landed with a bad foreman. However, complaints against individual foremen by the rest of the power station staff were very rare and pressures were often applied to foremen to make them conform to acceptable behaviour patterns. The outcomes of such behaviour patterns were accurately predicted by Thibaut and Kelley (1974) in their exchange theory. Under this theory the parties to an interaction would always adjust their behaviour until a satisfying outcome for both was achieved. Thus the hard line foreman with an indolent crew would either totally fail to work together or would both adjust their behaviour patterns until a satisfactory compromise was reached.

<u>The operations workload</u> Data from C.E G.B power stations showed a substantial part of the workload to be directed towards plant isolations and permits. Much of this was needless duplication arising from the demarcation of staff duties already discussed. However, many staff considered that much of the isolation workload was fundamentally superfluous. Examples were given of the isolation of 440 volt supply to a lathe and the issue of a permit before maintenance work was carried out. The procedures were also used for cold water town supplies. The third factor in this workload was the sheer volume of isolations related to the maintenance requirements. Operations staff considered the volume would be reduced if maintenance work were properly co-ordinated and efficiently carried out. It was also considered that the levels of maintenance were sometimes excessive. The only conclusion that can be drawn is that the high level of maintenance imposed an increased workload on the operations staff. More cleaning and routine maintenance of the plant was carried out by operations staff in American power stations which provided suitable "fill in" work for quiet operating spells. In the C.E.G.B. much of this work was done by the maintenance or special cleaning staff. The remaining cleaning workload in C.E.G.B stations arose from a lack of discipline on the part of the maintenance staff (both station and contractural staff) who failed to clean up behind their work. Much of this failure stemed from the time limitations imposed by the productivity scheme.

<u>Operations staff motivation</u> The opinions was frequently expressed during this study by all levels of staff that the work output per man was low. It was estimated that the number of hours worked per shift was about 4. Under the productivity scheme all work was timed and regularized and previously work had been categorized unofficially into that which was urgent such as correcting plant conditions; that which was routine e.g. oiling and greasing and checking plant; that which was "as and when" which included training, cleaning and minor plant checks. Motivation for the latter category of work arose from a sense of pride in the plant. At Downton station the manager had attempted to recreate this feeling by establishing unit crews

permanently assigned to a single unit. Also, information about the performance of the various units was regularly published. At Ash Haven the previously existing unit crews had been disbanded to meet the productivity scheme requirements. All the staff interviewed at this station wished for a return to unit crews and the pride in plant thus engendered. Under the productivity scheme the only requirement is to earn 8 credits per shift but under the earlier system the men's satisfaction came from their unit being on top line and preferably better than the other units.

Shift maintenance work

Much of the need for shift maintenance in C.E.G.B. stations probably stems from less reliable plant and this will be discussed later in the thesis. However, the Americans were proposing to have some shift maintenance in their high merit nuclear plant. The evidence indicated the advantages of having a shift maintenance crew orientated towards being supportive to the operations function. Closer co-operation appeared to exist at Fossil Strand where both crews were part of the same team. When normal maintenance was carried out on shift this seemed to be at the expense of the supportive function usually associated with shift maintenance. The argument for carrying out routine maintenance on shift would be that work was progressing for 24hours rather than 8 hours during the normal working day. The logic of this argument would be valid if the resources were limited e.g. it would be effective to operate a single machine 24 hours rather than for only 8 hours. But the group of three men deployed round the clock would not necessarily achieve more work than the same three men working together for 8 hours provided they could all be deployed at the same time. Since the average maintenance task in power stations was measured as lasting for 72 minutes this would imply that all the men could generally be deployed on the station without difficulty. Special circumstances sometimes arise (e.g. during major outages) and in these cases extended day working or shift work would be justified. In the American power stations such major outage maintenance was carried out by two shifts each working ten hours but this will be discussed in the next chapter.

The coal gang The important point to be made about these teams was that they only worked a three shift system due to plant inadequacies. These failings were apparently not present in the American stations. The other interesting factor emerging from the Ash Haven crew was the effectiveness of having a single level of management (namely foremen) for the group. This single level of management was probably a contributory factor to the unofficial abandonment of the constraint of the productivity scheme. The only real disadvantage was that because the rest of the station regarded the coal gangs as highly effective, little effort was made to improve the functioning of the coal plant. Although the inadequacies of the coal plant were brought home to the engineers who operated it during a strike they unfortunately did not pursue the plant problems following a return to normal work.

Shift teams as communities An overall sense of community was found to exist within the shift teams such as seldom was found on day work. This community had many similarities to a village where each of the households provides some service of benefit to the whole community in much the same way as the power station groups contributed to overall output. The comparisons could be pushed one stage further because some of the powerstation shift groups were close knit like a household and others had less well defined groupings whose existence was more a matter of shared facilities which could perhaps be compared to a lodging house. Some of the behaviour patterns would also stand comparisons and instances were given during the research of the way in which newcomers to a close knit group were gently coerced into the behaviour patterns expected. Other examples cited were of group expectations for the station management to include in their role the function of community policemen. Many frequently expressed their resentment of the way in which a few scroungers broke the community rules with impunity. Typical examples were that of individuals who would report sick when they wished to avoid an unpleasant job or wanted an unofficial day off at a socially desirable time (Saturday afternoon or evening) thereby requiring their workmates to provide cover. This community spirit encouraged a high level of co-operation and many expressed the view that it would have been heightened had a common shift rota been worked.

Summarizing the main points

Some of the more important points which have arisen in this chapter were as follows:-

1. The division in C.E.G.B. stations between engineering and industrial staff cut across what should have been a progressive series of jobs. This resulted in some duplication of work and unnecessary staff levels.

2. A sense of pride in the plant and a commitment to its operation appeared to exist in all the workforce.

3. Many of the rules and procedures were ignored by shift crews which accounted for their preference for working hours outside the standard 9 - 5.

4. Work output greatly in excess of 100 P.I. seemed to be possible but shift crews considered the typical day staff work output as providing their yardstick.

5. Routine maintenance on shift appeared to have little to commend it and seemed to lead to a deterioration in the community spirit.

6. Work planning and formal procedures seemed to discourage co-operation, team spirit and a pride in the state of plant.

7. The shortcomings of some of the C.E.G.B. plant appeared to give rise to additional shift work requirements.

The reader will be aware that opinions about the effects of shift work and the desirability of shift work have been excluded from this chapter since I have considered them sufficiently important to justify a subsidiary investigation. This is the subject of Chapter 10.

CHAPTER 6

PLANT MAINTENANCE ACTIVITIES

Introduction

As already mentioned in the introduction of the previous chapter these activities include all the maintenance groups with the exception of the shift maintenance teams whose function was essentially short term and related to keeping plant in operation. Maintenance work can be analysed in several ways: it can be classed as defect maintenance or preventative maintenance; it may be pre-planned or unplanned; it can be classed as work done during normal operating periods for the plant or that carried out during the major outage. In C.E.G.B. stations it is usual for all types of maintenance to be carried out by the same station staff, whereas in many overseas stations separate headquarters groups of staff will often perform some of the maintenance functions. The distinction is significant and affects the organizational size and its planned activities. Of the seven stations studied the three American ones had an average of 60 staff engaged in maintenance and the equivalent figure for the four C.E.G.B. stations was 322. This difference provides the main framework for the analysis of maintenance activities and I proposed to devote most of the chapter to a comparison of the overseas maintenance activities with those of the C.E.G.B. stations. Generally the increased workload associated with major outages requires additional resources and the American stations met this requirement by adjusting the size of the headquarters teams. In the C.E.G.B. there is no equivalent headquarters activity and as a result most stations used contractors for some of this work.

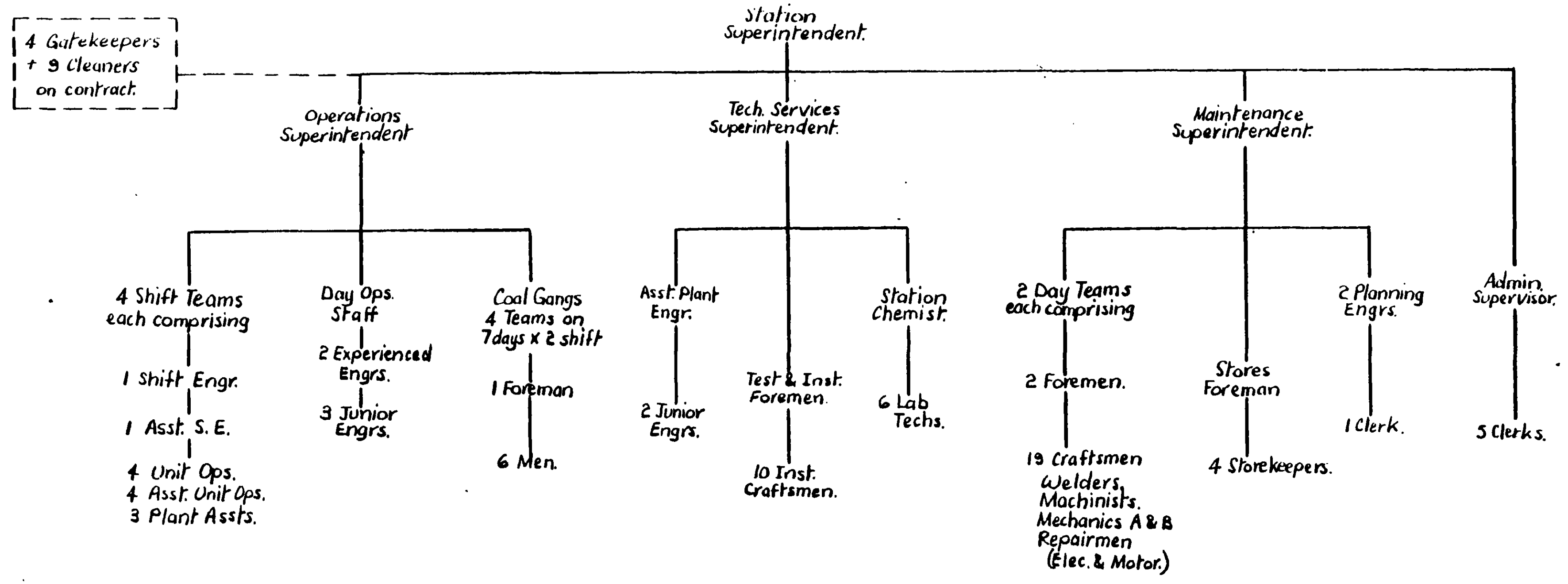
I shall start this chapter by trying to build up a picture of the maintenance activities in all the station studied but this picture must inevitably be sketchy since these substantial groups of staff perform a far more diverse series of tasks in a much wider range of jobs than was the case for the operations staff. I shall start with the overseas stations because the staff groups were so much smaller and the simplified picture will be easier to follow. I will then go on to the more elaborate structures used in C.E.G.B. stations.

Maintenance in overseas stations

In addition to the information obtained during my visits to three American power stations I have data on a fourth American station derived from the report of a visit by Cooper (1962) who was a C.E.G.B. station manager at the time of his visit. Some information on two French Power Stations was obtained by Buckley (1975) who made a six week visit under the Electricity Supply interchange scheme.

In American power stations the instrument maintenance branches are still a part of the test and efficiency department which is left over from the earlier days of power station organization when the only instruments were those used for testing purposes. In a later chapter I will show that the structure of contemporary American power station organizations are very similar to typical pre-nationalization U.K. stations. Thus changes in organizational structure have mostly been confined to the C.E.G.B. stations. For the purposes of this study instrument maintenance in American stations has been taken out of the test and efficiency branch which I have otherwise classed as a regulatory activity.

Marshall Steam Plant With the more complicated series of activities described in this chapter it will be helpful to provide the reader with some organizational charts and figure 6 shows the grouping of staff together with a classification according to activities. As can be seen, nearly half the staff are engaged in operating the plant. It is interesting to notice that both stores and planning are within the maintenance department and the maintenance industrial staff were divided into two teams to provide a seven day cover with a three day double team overlap at mid-week. This gave a working pattern of one weekend in two. The craftsmen provide a mixture belonging to



Total Staff 166	(13)	52	6	28	3	12	7	44	5	3	6
	R	C	R	C	R	M	R	M	M	R	R

Key. Activity.	Staff.	%.
C = Core	80	48
M = Maintenance.	61	37
R = Regulatory.	25	15
	166	

NOTE. Marshall Steam Plant is a station in the Duke Power Co. U.S.A.
It comprises 2 × 350 Mw
+ 2 × 650 Mw. coalfired units.

MARSHALL STEAM PLANT ORGANIZATION CHART.

SHOWING STAFF GROUPS CLASSIFIED ACCORDING TO ACTIVITY

FIGURE 6

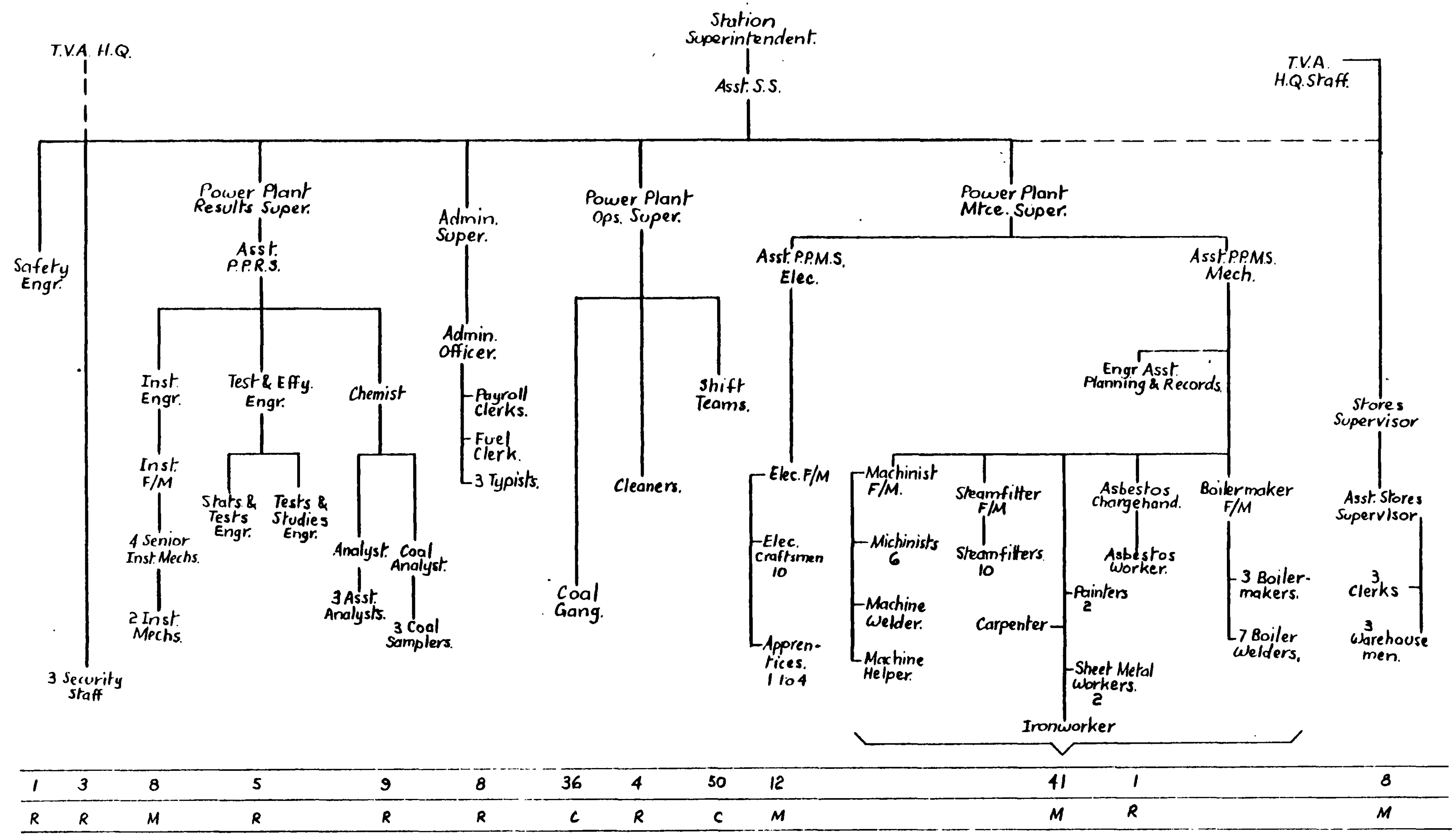
different unions and I was told that dismantling heavy electrical motors was classed as mechanical work. The station superintendent estimated that about 90% of the maintenance work on the plant was associated with the coal and ash equipment together with the sootblowers.

Bull Run Station More detailed information was obtained about the various crafts at this station and the organization chart in figure 7 displays this information. The percentage distribution of staff was remarkably similar to that for Marshall Plant.

The T.V.A. negotiated an agreement with the unions to allow greater flexibility of working. Under this agreement the number of jobs filled by members of a particular union would be proportional to the total workload associated with that craft. Thereafter the industrial staff were expected to work across demarcation boundaries to a reasonable extent. Some work specialization took place based on experience with different plant items. The foreman's role was that of expert in his plant area but he also ensured that work was progressing satisfactorily and organized the work in the short term.

The work philosophy for the instrument maintenance at Bull Run was set out in a paper produced by the departmental head. Instruments were tested and calibrated regularly as part of a planned programme of maintenance. All defects were expected to be dealt on a daily basis and it was stated that verbal reporting of problems was prefered to the writing of job cards. Thus close working links were maintained with the operations staff by the foremen and craftsmen. Lists of daily, weekly and monthly activities had been prepared together with set series of tasks to be performed whenever the unit was off load. The whole document occupied four pages and comprised the total work plan for the branch.

The general maintenance work pattern was similar to that for Marshall plant apart from slight variations in the staffing. The maintenance supervisor and his assistant dealt with any non routine technical problems and planned any major items of work. They had to ensure that



Total Staff = 186
(inc. T.V.A. H.Q Seconded)

Key.

	Activity	Staff	%
C ·	Core.	86	46
M :	Maintenance	69	37
R ·	Regulatory.	31	17
		186	

NOTE Bull Run is a Tennessee Valley Authority Station. It comprises 1 x 900 Mw coalfired unit.

BULL RUN STEAM PLANT ORGANIZATION CHART.

SHOWING STAFF GROUPS CLASSIFIED ACCORDING TO ACTIVITY.

FIGURE 7.

outage time was minimized and plant efficiency maximized. They were expected to co-operate closely with the operations superintendent. The junior engineers carried out the long term planning function and also kept plant history records. The foremen dealt with day to day matters, gave practical advice on the performance of work and organized work in the short term. The foremen said that most of the craftsmen took a pride in their work and in resolving problems and very little prodding was needed. Apprentices were given training at centralized workshops and then assigned to a craftsman at a power station to give them a gradual build-up of experience.

Many maintenance jobs can only be carried out when the plant is off load but are of the type which cause a reduction in efficiency but do not prevent the plant from operating. Just before my visit to Bull Run an unexpected outage arose due to a major slag fall within the boiler. The plant was expected to be off load for two days and lists of jobs for different types of craftsmen were prepared in order of priority. Additional staff were borrowed from another T V A. station and 12 hour shifts were arranged for the two days. Later it was discovered that the outage would be of five days duration and the T.V.A. headquarters then gave instructions for some of their longer term lists of plant modifications to be carried out. Additional welders were hired and organized into 12 hour shifts. The maintenance superintendent pointed out that the high overtime offered was the sort of incentive that enabled the workforce to be gathered together quickly. This hiring of additional labour is normally done through the local union representative. If management found a temporary employee was unsatisfactory they would tell the union representative who would ensure the individual was not offered subsequently. More casual labour appears to be available in the United States (at least in that area) and I was told that a substantial proportion of the labour force was content to work for approximately six months per year and spend the rest of their time at their home which typically might be a small-holding. Therefore temporary jobs offering high overtime levels were very attractive and many craftsmen were regular "casuals" who relied on power station annual outages for their blocks of casual labour.

Major maintenance for both stations was carried out by branches of the headquarters. In the Duke Power Company (Marshall station) the maintenance service was part of the power plant design and construction division but in the T.V.A. the group was part of the power production division. In both organizations, headquarters engineers dealt with the specialized engineering problems and provided a long term detailed planning function for major outages. At the Marshall plant I spoke to an engineer responsible for the major outage about to commence during which additional plant items were also to be installed. His status was the same as that of station departmental head and it was evident that he closely co-operated with the operations and maintenance superintendents of the station. I was told that typical career paths for engineers in these two organizations would be to start as a junior specialist engineer in headquarters and subsequently take a junior engineering post in a power station. This would typically be followed by a further period in headquarters and then a more senior post in a power station. Such a career pattern would promote the close co-operation between power stations and headquarters that appeared to exist. The power plant maintenance chief in T.V.A. headquarters gave me some details about the central workshops who provided the crews for major outages. The workshop itself had facilities for the largest type of work associated with the power station plant and provided all the technical expertise for work on turbines with a capability of handling ten simultaneously. For boiler work, technical expertise was provided by headquarters but much of the labour force came from the station. A typical headquarter's maintenance crew would comprise two specialists (usually ex power station craftsmen). There would also be two machinist foremen and eight craftsmen. The team would be split into a night shift and a day shift each working 10 hours on a six day week basis. All were paid annual salary plus lodging, food allowance, shift bonus and overtime. These crews would hire between twelve and fifteen hourly paid workers at the locality for the duration of a particular job. (Typically six weeks) For this hired labour the shift bonus and overtime would make the six weeks work the equivalent of about twelve weeks normal pay. The station would hire additional labour for the boiler and auxiliary work and the typical major outage crew would be the station staff plus twenty headquarter's staff plus about one hundred and fifty hired men for a total period of six weeks. Only very specialized jobs (e.g. chimneys) went to contract services.

Other overseas stations The other overseas station which I studied was Sequoyah and the maintenance work was based on a system identical to that at Bull Run with annual overalls carried out by headquarter's teams. When the third nuclear station in T.V.A. was commissioned it was anticipated that headquarter's nuclear maintenance crews would be established.

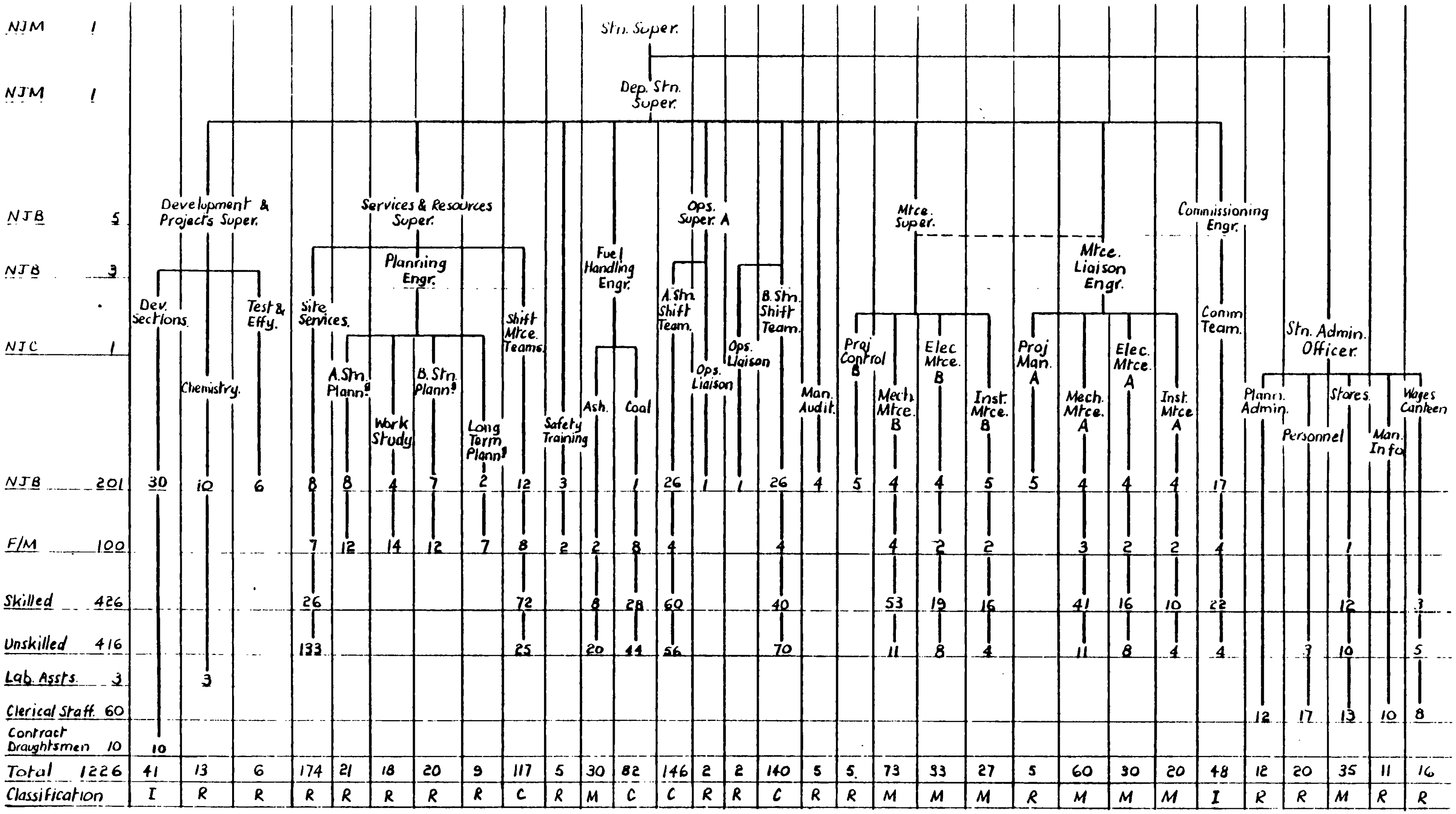
The visit of Cooper to the River Rouge Power Station of the Detroit Edison Corporation presented a very similar picture to that attaining at Marshall and Bull Run plants. This company had a construction division for building power stations which included a centralized workshop for dealing with major plant repairs and overhauls. The visit took place in 1962 at which period the company provided various incentives for staff and had adopted an approach to human relations which was influenced by Likert who was an advisor to the company and advocated group structuring along the lines set out in his published work (Likert 1961). A work simplification programme had been undertaken to encourage all employees to seek ways of improving efficiency. Very substantial awards were paid equivalent to a quarter of the first year's net savings. The fitters employed were placed in one of three grades according to their overall ability. The lowest grade was second-class in one craft; the next grade was first-class in one craft and the top grade was first-class in one craft plus second-class in an additional craft. Training was given by the company and all fitters were expected to progress to the top grade. Prior to the introduction of these changes one plant had engaged 120 men plus 8 foremen for maintenance work and is now operated with 19 men and 2 foremen. In non of the American stations studied were mates employed.

Buckley carried out a study at Martigue oil-fired station in France and noted that all the staff were on one scale which he believed to be a major contribution to the absence of the "us" and "them" attitude at the station. The maintenance department had a preparation section where seven individuals dealt with method study, planning, plant history and technical drawings. The work execution section comprised 85 staff divided into mechanical, boiler, electrical and instrument branches. Stores was a sub-branch of the maintenance department as was the case at Marshall plant.

Ash Haven maintenance staff

The organizational chart for Ash Haven is given in figure 8. Because it is complicated, none of the branches have been sub-divided. The core activity staff were displayed in figure 4 and in this chapter only the maintenance activities will be discussed. The percentages of staff associated with various activities are shown in figure 8 but for comparability with American stations the improvement activities would need to be discounted giving the following figures:- core activities 43%; maintenance activities 27%; regulatory activities 30%. Significant differences are the increase in regulatory staff and a percentage reduction in the maintenance staff. Even these figures are biased because a substantial proportion of the work associated with maintenance activities in C.E.G.B. stations was actually devoted to regulatory and improvement activities.

At this location the maintenance department was divided into two branches,one for each station. Each of these branches was sub-divided into four sections, one for each engineering discipline and a fourth for co-ordination and progress chasing on major maintenance projects. These fourth groups will be considered with the regulatory activities. The six active maintenance sections will first be analysed but with the substantial staff numbers involved I shall sub-divide them into engineers, foremen and industrial staff, and start the analysis with the engineers.



Key.

Activity.	staff	%
C - Core	485	40
M - Maintenance.	308	25
R - Regulatory	344	28
I - Improvement	89	7
	1226	

Note This Power Stn. comprises:-
A.Stn. 6 x 100 Mw. +
B.Stn. 3 x 500 Mw units, coal fired.

ASH HAVEN POWER STATION

ORGANIZATION CHART FIGURE 8

Maintenance engineers The standard practice at this station was to systematically move the junior engineers from post to post on a six monthly basis. The intention was to broaden their experience and turn them into "power station" engineers. The movement applied to junior and second engineers which comprised about two-thirds of the N.J.B. (engineering) staff. The engineers would move between the maintenance, planning and management service sections and even carry out shift work on operations. The most junior engineers generally accepted the system at its face value but the more senior ones universally resented the system and considered themselves quite capable of determining their own futures. At other stations,engineers were generally moved within the same discipline, such moves being in accordance with their wishes and preferences. This practice had a considerable affect on the organizational structure as the maintenance sections generally had four engineers in each,two of whom were permanent and two were peripatetic. A substantial proportion of the six months was spent in learning the work of the section and this resulted in a lowering of the effective work output. All the managing and organizing within each section was carried out by the permanent engineers. Thus the number of engineers on the station did not necessarily reflect the station's engineering workload.

Many engineers described their work during the attitude survey and one or two extracts will be used to build up a picture. For the more senior engineers who were typically section heads, the day normally commenced with morning meetings with planning, operations and shift maintenance engineers in attendance. The day's work programme would then be decided unless the subsequent management morning meeting caused it to be modified. The planning department then prepared work cards for the following day when the foremen would issue them. Much of the engineers time was spent in progress chasing and holding technical discussions about problems and making short term decisions. The plant was regularly visited for good human relations and checking on its state. A continuous source of work was dealing with labour troubles arising via the shop steward. Finding alternative suppliers for materials also absorbed a considerable amount of time.

For second engineers (about midway up the hierarchy) the typical work pattern was a steady stream of minor technical problems and requests with some days being relatively quiet. Several longer term projects would normally be in hand and these would typically be modest sized modifications to plant. Larger modifications were carried out by the development department but the post holder would be involved by the need to monitor contract work in association with them. Much of the work required a general engineering ability plus a little management together with a need to supervise contractors staff. A typical engineer considered that between a third and half of his time was spent on administrative aspects, obtaining spares and equipment etc.

Many junior engineers were given technical responsibility for certain plant areas and they would normally tell the section head (usually a first engineer) about the proposals. This telling would serve the purpose of getting advice, keeping the engineer informed and obtaining approval. He would then prepare a work order card and put it into the planning system. He would subsequently be told when it had been programmed and would then contact the foreman, who would allocate individual fitters to the job. He spent a considerable proportion of his time on the plant often working with the men as a member of a team. Upto two-thirds of his time was spent on the plant with the remainder in the office preparing modifications or drawings or dealing with administrative aspects such as going out to contract, contacting suppliers, preparing specifications.

The maintenance foreman's role At this station each group of foremen had two sets of duties, namely those as line foremen and those in the planning office. Thus at least half the foremen's time was spent on administration. Their duties were changed every six months. The works office foreman's job will be discussed in the next chapter within the planning section. The line foreman's duties could be further sub-divided into those associated with the workshop and those covering a plant area. There would normally be one line foreman on duty in each station for each discipline. Because of seven day working, two foremen were normally required to cover each duty. Typically, foremen would start the day by setting the work programme in motion and ensuring that all fitters had job cards. He then attended meetings with engineers which often resulted in the work programme being changed. They tried to get around most of the jobs in progress during the day the object being to monitor the work, maintain good human relations and to offer help and advice if required. They frequently provided a service for fitters by dealing with problems causing delays such as missing stores items or the lack of permits to work. Difficulties sometimes arose for the workshop foreman because he clearly is in a position to monitor the work of fitters much more closely and far more frequently. Many fitters resent constant surveillance and the workshop foreman often carried out certain administrative tasks such as time keeping records on behalf of the section. Throughout the day the line foreman kept the works office foreman appraised of the work progress so that the latter could update the following day's programme. He would also report difficulties, delays and urgent problems. Sometimes at this station,line foremen would raise job cards and he would normally spend a quarter of his time dealing with administrative aspects of the productivity scheme. A further quarter of his time was spent in communications with engineers, other branches, stores etc. with the remaining half devoted to line duties.

Industrial maintenance staff The three disciplines for the two stations provided six groups of staff each of which was sub-divided into four to provide for seven day working and minimise the overlap peaks. Three weekends in four were worked but the social groupings of the staff were based on the workshops and included the total number of fitters at work on any day.

Mechanical fitters were arbitrarily allocated to turbine or boiler work at their initial recruitment and tended to stay within that category indefinitely. Friendly banter existed between the two groups with the turbine fitters considering their work to be more demanding than that of the boiler fitters. Other fitters designated as turners would stay in the workshop,but for most the typical workload comprised dismantling equipment such as pumps and valves, cleaning and refitting components, repacking glands and gaskets, replacing bearings and then reassembling the items. Some fitters would specialize on items such as compressors. Because of the noisy and dirty state of the plant items would be removed to the workshop for dismantling whenever possible.

Welders tended to keep themselves apart from the fitters and considered themselves to be a cut above the latter even though the fitters considered them to be a shade below because they did not usually serve an apprenticeship. Welders spent a considerable part of their time moving equipment about the station, finding supply points and preparing to work. Also much of the welding time was mis-applied in their opinion because it was low grade work such as cutting off bolts and most of the welders were classed as grade 1. Nearly all the grade 1 welding on the site was carried out by contractors. The mechanical fitters mates generally worked under the direction of a fitter and got involved in dismantling, cleaning and reassembling equipment. Most of the comments about work made by the thirty mechanical fitters interviewed were critical and especially critical of the productivity scheme. Some of the points made were as follows:-

"Division into turbine and boiler fitters is alright but some interchange should be possible."
"Lack of spares result in delays and fitters doing "bodging" jobs. Stores seem to forget that they are providing an essential service for fitter."
"In the merchant navy promotion prospects were much better with no sharp distinction between fitters and engineers."
"The job card system makes no allowance for differences between undoing easy and accessible bolts and corroded ones which are inaccessible."
"The works systems detract from job satisfaction because they don't allow the individuals to finish jobs which they have started."
"Most people fabricate work on the cards to establish a long enough time to do a proper job."
"Most of the interesting work is done by the contractors."
"On an Esso plant all support services were available to fitters who use their discretion in relation to the extent of work done on the plant."

"The operator would inform a fitter if the work were urgent."

"Poor work is often done by fitters adhering to the instructions of the work order card and trying to keep within the proper times."

"Before the productivity scheme jobs were given out and the fitter was expected to take as long as necessary."

"Under the old system (before the scheme) men would come in at 8 o'clock and within five minutes would he heading towards the plant with jobs to carry out; men worked harder and were happier; plant maintenance was at a higher standard."

"Work done under the old system was better and cheaper than that done by contractors, the No.1 unit recently overhauled by contractors is being reworked."

"In the old days chargehands would allocate jobs they saw needed doing and they took a personal interest in the plant."

"Typical boiler work would be the moving or replacing of burners which required a team comprising a welder, a fitter, a rigger and a mate."

"Most larger scaffolding jobs are now carried out by contractors but use to be done by power station staff."

"Putting a scaffolding inside a boiler usually takes three days and needs three riggers plus mates."

"The total work output of the riggers has been much reduced by the productivity scheme, before that the foremen ensured that work pressure was maintained, made decisions and co-ordinated services."

"Nowadays equipment is taken to a job in accordance with a programme and then it is discovered that it cannot be carried through so the job is abandoned."

"The planning system isn't as flexible as the old system of personal supervision by a foreman."

"Before the scheme the basement was cleaned every shift and now it is never cleaned."

"Very low times are sometimes given for jobs in the scheme due to the foreman failing to write enough detail onto the cards in order to ensure a proper timing; but foremen don't have sufficient time to write out all the details."

"Apprentice training standards are extremely poor at the station; they are now used as mates and previously a craftsman would "shadow" an apprentice and give advice at appropriate times."

"The pace of work at the station is low and most men prefer a faster pace of work."

"Under this scheme a fitter requests a foreman for services of a rigger, the foreman feeds the request into the planning office and then out to the rigger; therefore the fitter spends a great deal of time standing about waiting for a rigger."

"Many of the unavailable items in the store are commonplace such as standard bolts."

"The impersonal nature of work planning frequently precludes the satisfaction of dismantling something; correcting the fault and reassembling before testing."

"Some jobs are done in "half baked" manner because of the short times allocated. E.g. a gland might be half repacked which will temporarily solve the problem but mean it will have to be done again much sooner than would have otherwise been the case."

The above quotations may help convey something of the attitude towards work as expressed by some of the mechanical maintenance fitters. Very similar quotations were given by electrical and instrument fitters. Clearly, the latter shared the same working conditions as the mechanical fitters but usually not quite to the same extent since more of their work would be done in the workshops. They frequently stated that the adverse plant conditions materially contributed to the level of plant defects.

<u>Other plant maintenance activities</u> The other two groups whose duties have been classified as plant maintenance were the ash crew and the stores section. The ash crew comprised two teams of fourteen men plus foremen who jointly covered the seven day week. Most of the jobs were driving large construction site type tipper lorries which were used to move the ash from the plant storage silos for dumping in the more remote parts of the site where it was used for land reclamation. A certain amount of dry ash was bagged for sale (like cement) and an individual would be allocated to this dusty job for a day at a time. All of the work could be classed as semi-skilled and the physically easiest jobs generally went to the older men.

The stores section were the cause of much frustration by their "customers". Engineering stores frequently caused frustration as any motorist who has every waited at a main agent stores counter will know. The power station system required fitters to look up the code number (out of well over 20,000 listed) and then ask for the item by number. Stores catalogues are frequently changed causing fitters difficulty in tracking down the part they want and many items appear under more than one code number. At Ash Haven there were two stores one for each station but the main store was in the old station. A 24 hour service was nominally provided at the old store but was closed overnight while the staff carried out stocktaking (perhaps a new name for resting). The 'B' station store was only available between 8 a.m. - 4.30 p.m. but was suppose to open on demand at any time. However, the stores were half a mile apart, separated by a windy coastline, and written permission was required to have the 'B' station store opened out of hours. These conditions were almost equivalent to saying the store would not be open.

The storekeepers maintained that they tried to be helpful but it was impossible to know more than about half the items commonly in use. In addition to serving at the counter the other storekeeper's duties included receiving goods, opening packages and checking invoices. They also carried out stock checking.

Fossil Strand plant maintenance staff

At this station all the maintenance activities were studied but the electrical maintenance branch was the subject of a deeper investigation and will be described here.

Electrical maintenance The branch head held the grade of senior engineer and was accountable to the maintenance superintendent who was a principal engineer. Some degree of antipathy existed between these individuals resulting in the branch head exercising a much higher level of autonomy than was the case at other stations studied. Because the electrical maintenance branch was regarded as efficient by the rest of the station, this situation was allowed to continue. The branch was divided into four sections each with a section head (first engineer) and three of these were line sections, the fourth being services. One of the line sections covered the 'A' station the other two splitting the 'B' station into conventional plant and nuclear plant. The main reason for the 'B' station's much greater work input was the high level of plant modification and development work still to be carried out to overcome the post-commissioning technical problems. The services section had responsibility for the shift teams, the workshops and the branch planning function. Each of the three line sections comprised three or four engineers (mostly second engineers) each of whom was allocated an area of plant for which he was technically responsible. The two 'B' station sections then shared industrial staff which for each station comprised three foremen and about twenty fitters and mates. All the engineering staff worked a five day week and all the industrial staff worked a seven day week. One of the three foremen acted as relief and the other two each had line responsibility for a substantial plant area.

Those second engineers who were able to establish a rapport with the foremen were much more successful in getting work done than were those who were conscious of their rank and who subsequently found the foremen insisting on using the formal line of authority via the section head. The engineers working patterns were similar to those for Ash Haven with the exception that electrical engineers tend to spend more time working on the plant than do mechanical engineers. This is because certain tests (e.g. high voltage switchgear) have to be carried out by suitably authorised engineers. For the rest of the time the engineers would be typically investigating plant problems, deciding on solutions and initiating the work by raising work order cards. They would also investigate larger problems as plant improvement projects and spend time preparing drawings, specifications and contacting suppliers. The section heads would find themselves trapped into a routine of attending meetings, co-ordinating work and making short term policy decisions.

The line foremen at Fossil Strand were not so involved with the productivity scheme because a separate foreman was assigned to the works office for a period of approximately 2 years. This enabled the line foremen to concentrate on the monitoring and facilitating of work by the industrial staff although the administrative aspect still occupied about a third of their time. They also took an interest in the state of the plant and raised job cards for many of the more straightforward maintenance items which normally did not involve technical problems. The foremen also organized minor jobs outside the planning system to assist their opposite numbers in other disciplines. (e.g. arrange an electrical motor disconnection to enable mechanical maintenance foremen to organize work on a pump.) During his day the foreman would expect to visit the plant several times and would also contact the works office foreman several times to keep him informed of progress. He would normally try to arrange for one fitter to be on unimportant work which could be dropped to deal with urgent defects should they arise.

In my discussions I formed the opinion that the foremen assigned to plant areas on a permanent basis appeared to have a greater sense of responsibility for the plant than did any other group of staff on a location. A contributing factor towards this was that the foremen were normally older men at the top of their career progression. The engineers with technical plant responsibilities were generally younger engineers expecting to progress further within the organization. The section heads had a similar sense of responsibility towards the plant but their duties prevented them getting sufficiently involved.

The patterns of work for the electrical fitters and mates was mostly defined and controlled by the paperwork system. Tasks were allocated and timed by work order cards and the work to be carried out was set down on a specification. Stores were obtained on requisitions and working hours were recorded on time sheets, clock cards and leave forms etc. The average fitter spent about 7% of his time on paper-work and about 10% collecting materials from stores. 80% was spent carrying out a variety of tasks and the typical pattern was two average size tasks per day. Sometimes tasks would last several days and occasionally a day might be made up with about ten short tasks. All the fitters were suppose to be able to do all the tasks but a certain amount of selection of individuals for tasks was carried out by the foremen who took into account attitudes, experience and preferences. The men felt they could influence such selectivity by requesting the opportunity to work on another type of task.

The work ranged from heavy mechanical type associated with large electric motors to electronic work on circuit boards etc. A great deal of the workload came in the middle of the range covering medium sized electric motors and a great deal of switchgear. An alternative way of assessing the work would be to divide it into routine and breakdown (defect) categories. At this station the intention was to achieve 50% preventative maintenance and 50% breakdown work. The fitters generally preferred defect work because it was more interesting.

Fitters mates were assigned to tasks where two men were required and were suppose to carry out the unskilled and cleaning aspects together with the fetching and carrying. In practice most mates preferred to be involved in the total task and most fitters encourages them to do so. On some power stations a higher grade of mate is used called a battery attendant whose job included topping up batteries, changing bulbs etc. without close supervision. This did not take place at Fossil Strand because the fitters were jealously guarding their craft status even though most disliked this semi-skilled type of work.

At a nuclear station the electrical workload is about double that of a conventional station due to the more sophisticated nature of the plant and a much higher level of duplication. Also, much more stringent standards of maintenance are required resulting in a greater frequency of preventative maintenance. In one year at the 'A' station the workload included the servicing of 3,000 batteries per year; the regular checking of 2,000 electric motor brushgear sets; 800 contactors and circuit breakers were maintained and about 20,000 light bulbs and tubes were changed.

As a part of this research one complete block of the annual work cycle for the branch was analysed and the opinions of the staff carrying out the work were obtained.

Statistical survey of tasks The block of work chosen was the preventative maintenance programme for the 'A' station which was about a quarter of the branch's total workload. Tasks were grouped into eight categories and each task was assessed by representatives of the fitters on the basis of job interest, working conditions and perceived need for the work. A total of 2,670 tasks were analysed and the breakdown into work types is shown in Table 6.

TABLE 6 FOSSIL STRAND 'A' STATION

ANALYSIS OF ROUTINE ELECTRICAL MAINTENANCE WORK

Type of Maintenance	Planned hrs. per year	% of Total
Electric motors and controls	7,484	30
Lifts, cranes and hoists	4,760	19
Lighting (tubes and bulbs)	4,126	17
Batteries, transf. oil filters	4,012	16
Vehicles, domestic & sundry	1,895	8
Switchgear, busbars etc.	1,491	6
Small motors, fans etc.	477	2
Main sets, sliprings etc.	448	2
Total hours	24,693	100

Lifts, cranes and hoists involves work on electric motors and controls but the working conditions are usually difficult. Thus these first two categories of work comprise about half the total for the electrical fitters.

The assessment of work satisfaction for each job was obtained by assigning a score from one to ten for each of the three parameters listed. The scores were multiplied by the total numbers of hours spent on each particular job per year. The results when totalled gave satisfaction figures for this block of work. The results are set out in Table 7.

TABLE 7 FOSSIL STRAND 'A' STATION ELECTRICAL MAINTENANCE

WORK SATISFACTION FACTORS FOR ROUTINE TASKS

Parameter	A = planned man hours	B = planned man hours x ratings	Average Ratings = B/A
Job interest	24,693	98,486	3.99
Working conditions	24,693	117,508	4.76
Perceived need for work	24,693	124,668	5.05

The electrical maintenance industrial staff at this station were reasonably satisfied with their work and yet the job interest only rated a score of four which seems rather low when the men were rating the jobs against work expectations. A score for working conditions of approximately five also seems low bearing in mind that Fossil Strand is a comparatively clean station. Perhaps the most disturbing figure is the need for the work which only rated five and this represents the assessment of trained craftsmen. The need for higher maintenance standards on critical items of plant seemed to have been considered by the staff since such tasks consistently rated fairly high. Thus the low figure for the perceived need for work took into account the type of plant. The indication is that either the engineers had failed to convince the fitters of the need for the work or the fitters had failed to convince the engineers that much of it was unnecessary.

Analysis of the maintenance function

On the Marshall plant the simple maintenance framework comprised small groups of fitters together with a minimum of supervisory staff. (Also note that no mates were used at this station.) All routine and breakdown maintenance was covered by two teams working a seven day week and totalling 48 staff. The work was supervised and organized by three foremen and policy was determined by two engineers who also provided any technical problem solving. Before going deeper into this study it would be useful to establish whether the Marshall plant figures were typical and also whether the Ash Haven figures were a reasonable representation of the staff levels common in C.E.G.B power stations. The maintenance figures for the seven stations studied in this research are given in Table 8 together with equivalent figures for the two French stations reported by Buckley.

TABLE 8 COMPARATIVE MAINTENANCE STAFF LEVELS

	Fuel Type	Engrs.	Fore-men	Ind. Staff			Total Staff	H.Q. or Contr.	O'time %	Total equiv. Work-force
				Mech	Elect	Inst				
Marshall	Coal	2	3	26	12	10	53	20	15	86
Bull Run	Coal	3	5	36	10	6	60	20	15	94
Sequoyah	Nuc.	6	6	37	12	7	68	25	15	109
Martigues	Oil	3	7	47	9	11	77	27	7	112
St Laurent	Nuc.	3	17	43	26	19	108	40	7	159
Ash Haven	Coal	37	23	168	79	50	357	250	7	653
Fossil Strand	Nuc.	90	41	170	76	68	445	50	7	529
Downton	Coal	26	21	116	36	32	231	60	7	313
Olliton Reach	Oil	28	18	126	39	45	256	150	7	437

The figures for the American stations all fit into a pattern and during my visit staff totals for several other T.V.A. power stations were provided. Examples:-

Gallerton	4 unit coal fired	Total staff 130
Chawnee	10 unit coal fired	Total staff 165
Johnsonville	10 unit coal fired	Total staff 263

These totals are very much in line with the total staff for the three stations analysed. For the C.E.G.B. stations, information about staff numbers at similar stations in other regions was not available but the few figures obtained indicated some congruence. For example, the average total number of industrial staff at the four stations studied was 724 and an equivalent average value for eleven similar stations in other regions was 750. The average figures for the C.E.G.B. stations are over five times the American figures. The figures for the two French stations were comparable to those of the American stations.

The figures in the headquarters or contractors column of the table have been derived as already explained by taking the number of "team weeks" for American stations and converting them into the equivalent "man years". A similar procedure has been adopted for the French stations. For the C.E.G.B. stations the figures relate to contractors staff derived from actual numbers or from a figure equivalent to one third of the revenue contracts value. It would seem as though the overseas practice of using headquarters staff belonging to the organization will offer certain advantages:-

Similar pay rates and conditions of service could be imposed.
The job rewards of high overtime rates would suit the organizational requirements.
The workforce would accept some responsibility for the plant state.
The station staff and the headquarter's team would work together.
The availability of variable sized teams from headquarter's would enable the stations to operate with minimum steady state staff levels.

The American stations found that an important requirement was to ensure that their station staff were able to work as much overtime as required and 15% was an average figure. For the C.E.G.B. stations 7% was the average figure and this has been used for the French stations. At

Ash Haven Power Station there were an average of 500 contractors staff on site during the period of the research and these men with their high pay rates were the cause of much discontent. One interesting point to note from Table 8 was that Downton station had a much smaller maintenance force than did Olliton Reach. The management at Downton estimated that half the maintenance effort was involved with equipment associated with coal-firing (coal and ash plant, mills, bunkers etc.). On this estimate Downton's maintenance staff would reduce to 156 if they were to be comparable with the number at Olliton Reach (437). Another point to be noted is that nearly half the routine electrical maintenance workload at Fossil Strand was the servicing of electrical motors and controls. It must be assumed that the majority of this effort went into the removal, dismantling, component replacement and reassembling of electric motors. It is also evident that such practices are not carried out in the American stations since the manning levels would be quite insufficient to support the work. There is also at least a suspicion that much of this work is unnecessary since the perceived need for it was only rated at about half by the fitters. One small point which I picked up when analysing this workload was that all domestic appliances in use at Fossil Strand by shift teams etc. had a routine inspection each quarter. Thus electric toasters and similar units would be opened up and checked on a regular basis. Having been an owner and user of just such a toaster for well over 20 years I have only found it necessary to carry out breakdown maintenance on three occasions and from that experience I can conceive of no possible reason why such an item should have been dismantled, checked and reassembled about eighty times. I was told that much of the work at Fossil Strand was a requirement of the Nuclear Installations Inspectorate. This requirement seems to place the responsibility for the frequency of maintenance on that body and station staff agreed that much of the work carried out was excessive. The station staff also agreed it might well be possible to reduce the frequency of such maintenance but that the administrative requirements and meetings to achieve it would make it a formidable undertaking.

Despite the very high maintenance staff levels associated with Ash Haven plant the station problems seem to be unending. One very senior member of Regional management was once heard to express the wish that he could "tow the station out to sea and sink it." Although the new plant has many inherent faults, the old station once had a performance record approaching that of the Marshall plant. At that period of its life it was high in the merit order and maintained in an immaculate condition operating with a high efficiency. The reasons most frequently expressed by the staff for the change were the different management style; the disbanding of work groups and teams associated with the introduction of the productivity scheme; the proliferation of "chiefs" (engineers) with jobs unrelated to plant requirements. When considering station staff levels the performance figures should also be taken into account. In general, the C.E.G.B. stations studied had performance figures significantly worse than the overseas ones. The efficiency figures much lower than those of the American stations studied or the French ones reported. Martigues (oil) had an availability of 94% in 1974 and St Laurent (nuclear) had an availability of 69% in 1974 (one reactor had a major programmed shutdown). In 1975 the availability of this station for the first six months was 90%. In the French stations high availabilities are attained with the minimum of routine maintenance. This would also seem to apply to the American stations. The availability of Marshall plant in 1975 was 86.2% and its efficiency was 38.1%. The figures for Bull Run were not obtained but since it was higher in the American merit order than the Marshall plant, the figures must have been better. The Fossil Strand 'A' station had reasonable availability figures with an average over the last five years of about 75%. It is also interesting to note that Olliton Reach Power Station had very high maintenance staff levels (bearing in mind its size) and this was the station with a propounderance of maintenance carried out on shift.

<u>Analysing the engineers work</u> The jobs of nearly all the maintenance engineers at the four C.E.G.B. stations had been analysed and an indication of their working patterns has already been given. Many meetings such as the daily planning meeting generated a series of

sub meetings. Many of the section heads held two meetings before the main meeting, one with the foremen and one with the engineers. Usually two further meetings followed the main meeting to pass on policy decisions.

The average allocation of time for all the maintenance engineers studied worked out as follows:-

1.	Technically supervising maintenance work in progress	25%
2.	Investigating plant faults	20%
3.	Planning and co-ordinating work	15%
4.	Organizing supplies and spares	15%
5.	Carrying out plant modifications	15%
6.	General administrative tasks	10%

These percentages raised some important questions e.g. could the technical supervision of maintenance work be carried out by the foremen? Many fitters considered that engineers investigated plant faults which should have come within the competence of a skilled fitter. Planning work and organizing supplies took up nearly one third of the engineer's time in activities not related to their skills. If power stations were designed and constructed by the owning organization, would such a high level of plant modification work be necessary?

On alternative way of analysing the work is in accordance with function and this was done for all the maintenance engineers at Fossil Strand, Downton and Olliton power stations. The results are presented in Table 9 and are derived from a breakdown of each task for each engineer at each of the stations. In this table the section heads are not included which accounts for the relatively low figures for management and supervision. Shift maintenance engineers have higher values for these functions because they exercise line responsibility over the foremen even though they are second engineers. The group of electrical technicians at Fossil Strand spend half their time making routine checks of high voltage electrical switchgear and the bulk of their remaining time was spent investigating problems with the same equipment

TABLE 9

MAINTENANCE ENGINEERS TIME ALLOCATION

PERCENTAGES ON VARIOUS FUNCTIONS

STATION	DUTY	M	S	P	TE	T	A	TOTAL
Fossil Strand	2E Mechanical	7	9	7	52	9	25	109
	2E Electrical	2	7	12	49	15	31	116
	Elect. Technicians	-	7	3	25	49	28	112
	2E Instruments	6	8	8	42	16	29	110
	SME Mechanical	13	13	4	51	6	20	107
	SME Electrical	6	4	17	45	23	11	106
	SME Instruments	11	13	12	35	29	3	103
	SME Computer	2	10	10	52	18	15	107
Downton	Mech. & Heavy Electrical	6	13	3	34	5	45	106
	Light Elect. & Inst.	3	13	11	32	23	30	113
	SME Mech. & Heavy Elect.	7	23	3	30	13	29	105
	SME Light Elect. & Inst.	10	20	3	35	20	19	107
Olliton	Mech. & Heavy Electrical	4	6	3	27	16	38	104
	Light Elect. & Inst.	4	8	5	34	17	38	106
	SME Mech. & Heavy Elect.	7	14	2	28	12	42	105
	SME Light Elect. & Inst.	2	10	4	22	45	24	107
Averages	Day Mechanical	6	9	4	38	10	39	106
	Day Elect. & Inst.	3	9	8	36	24	31	111
	Shift Mechanical	9	17	3	36	10	30	105
	Shift Elect. & Inst.	6	11	9	38	28	14	106
	Day Engineers	4	9	6	37	17	35	108
	Shift Engineers	7	14	6	37	19	22	105
	All Maintenance Engineers	5	11	6	37	18	29	106

KEY:-
- M = Management Functions
- S = Supervisory Functions
- P = Professional Engineering (use of theory)
- TE = Technical Engineering (use of experience)
- T = Technician Work (practical work)
- A = Administrative Functions
- TOTAL = Time at work. 37½ hrs. = 100%

or keeping plant history records of the work carried out. The mechanical engineers generally spent less time doing practical work on the plant because of the tendency for mechanical faults to develop gradually requiring investigations and engineering value judgements on the part of engineers. Also there is only a little mechanical plant work requiring the greater sense of responsibility expected of an engineer for its execution. One example of this type of requirement was that certain mechanical adjustments and investigations were carried out by the engineers in parts of the reactor where only limited access was possible.

The engineers in American stations appeared to spend a similar proportion of their time on activities such as obtaining spares, dealing with obsolescence, considering plant improvements and planning as was spent by C.E.G.B. engineers. For the American (and French) stations these activities become insignificant in terms of manpower. All the activities seem to centre around the same basic problem which is the need for a much higher level of work input on C.E.G.B. plant than was the case on American plant. However, one operations superintendent said it was very easy for engineers to be carried away by plant improvements and that it was always possible to make further improvements to existing plant. He considered that the job of power station staff was getting new plant into a workable condition and then operating it. A similar outlook was expressed by a member of senior Regional management who said that a major policy decision was necessary about expenditure on existing plant. He expressed the view that C.E.G.B. purchasing policies had given us low grade plant (described as 50% plant) and a decision was; whether to spend the other 50% on converting it into first-class plant or whether to use the money on building new higher quality plant. These aspects will be discussed in Part 4 of the thesis when looking for an answer to the question:-

"Did we BUY second rate plant" or
"Did we GET second rate plant"

I was told that Marshall plant had cost $100 per kilowatt which would have been between £40 and £45 at the rates of exchange then prevailing and this was the level of price paid for our contemporary stations. An alternative reason for our high maintenance staff levels might be less effective working methods and in the last part of this chapter I will try and draw some conclusions relating to that suggestion.

Maintenance activity conclusions The practice in the American stations could be simply outlined and consisted of one man (the engineer) to determine the policy for a maintenance function. He was also regarded as a technical expert for that plant and either solved technical problems or called in the appropriate headquarters staff. He was a member of the station management team and therefore tailored the maintenance policy to the station requirements. Under him one or more foremen were concerned to implement that policy on a day to day basis and they had the responsibility for programming work, supervising the workforce and providing practical knowledge (based on experience) to plant problems. The industrial staff were all trained to be able to deal with all the plant items in their work schedule and they were expected to use their skills and discretion in determining what required to be done. They were also expected to make entries in the plant history records for those particular plant items. Systems for work recording and work planning existed but they were only used when work could not be dealt with immediately. Generally this related to work to be done on outages which was incorporated in the plan. Even these plans were very flexible as the example given from Bull Run showed.

The picture presented by C.E.G.B power stations was very different the intention being to carry out as much preventative maintenance as possible and this resulted in elaborate planning schemes. These schemes, together with the productivity scheme, necessitated work timing and this in turn required a statement of the work to be done and how long it should take. The exact process will be described in the next chapter but its general effect on the industrial staff was to demotivate them by taking away any initiative. This topic was a recurring theme in all the interviews held and one recorded example went as follows:- a fitter was being disciplined by a senior engineer for having carried out maintenance work on a pump without correcting a defect and this resulted in the pump being damaged. The fitter said he carried out the instructions as on the job card. The engineer said the fitter must have known that the defect would lead to the pump being damaged and so why did he leave it. The fitter replied that previously on a maintenance job he'd carried out work in excess of the job card instructions because he had felt it to be necessary. He had exceeded the laid down time and had been told by the foreman to stick with the system and do what the job cards said. In practice most of the industrial staff were too proud to work the system exactly and used various methods to circumvent the system. One was a tendency to invent work on the equipment in order to create enough additional time to do the basic job properly. On other occasions the fitters would skimp the work in order to try and meet the time.

Because of the inherent delays in the planning system and because in a power station it is a good general principle to get all maintenance work done as soon as possible, the engineers and foremen who collectively were responsible for the completion of maintenance work ended up spending their time chasing, organizing and re-adjusting work timetables. The more senior engineers spent a considerable proportion of their time at meetings which were also concerned with pending work. None of this workload existed in the American stations since there was virtually no work to be planned. It had all been done. Generally in the C.E.G.B. an engineer had responsibility for plant areas. Foremen also had responsibility for plant areas, although this was generally self-imposed. Unless plant is in need of modification or is seriously mal-functioning there would seem to be little need for qualified engineers to be allocated to each part of the power station plant. It was noticeable in the coal plant at Ash Haven that the staff motivation was very much greater when responsibility for all the work on the plant and with the plant was carried by the foremen who also worked without the constraint of the productivity scheme. Their only difficulty was that the plant improvements requested were seldom carried out. It would seem that in the C.E.G.B. maintenance structure a major duplication of effort occurs and in this work area (unlike the operations) the superfluous staff layer would appear to be the engineers. The other major constraint would appear to be the planning systems. The demoralizing effect of these two factors on the industrial staff might be a major reason for the very low productivity which was estimated and measured at all the power stations studied and produce an average work figure of 50% productivity. It is also doubtful whether the nominal 100% productivity would be equivalent to the output of well trained and motivated staff such as appeared to exist in the American and French power stations.

If as was suggested, 50% of the work carried out is unnecessary and if the inferior plant perhaps doubles the amount of necessary work then these two factors would account for four times the work being carried out in C.E.G.B power stations. If productivity was increased by two and a half times, this additional productivity would be more than enough to account for the discrepancy between C.E.G.B. and overseas manning levels. In the case of the foremen, a study of their jobs indicated that up to 75% of their work was administrative and concerned with the short term work planning and the productivity scheme. It is thus easy to account for the factor of four in the case of the foremen. If the maintenance engineers in C.E.G.B. power stations have any role to play other than manning the function it must be the engineering problems associated with inadequate plant. Routine maintenance or replacement of satisfactory but worn equipment can readily be dealt with by foremen and industrial staff. Major technical problems should be the concern of specialists and these exist in the C.E.G.B. Regional Headquarters in much the same way as in the American organizations. The only major difference is that in the case of the C.E.G.B. these engineers are seldom used on practical problems in power stations.

Because the pay levels for industrial staff were relatively low at the time of this research it is probable that many of our industrial staff are not of the highest standard available. Certainly, at Ash Haven power station it was only possible to recruit the less well trained instrument mechanics for example and they usually left after they had acquired sufficient plant experience to be able to command a job in a better paying industry. The practice in T.V.A. was to pay rates equal to the best in the district and the declared practice of Detroit Edison (reported by Cooper) was to pay rates higher than the average in the area and so attract the best grade of staff. In many modern Japanese factories the numerically small workforce is often comprised of relatively highly qualified staff roughly equivalent to our technician qualifications. On this basis the engineers in C.E.G.B. power stations would have a role to play because they would be the individuals carrying out the work. About 75% of the engineers are qualified as technicians. A considerable number of the industrial staff were similarly qualified.

<u>Summary</u> The C.E.G.B. power stations probably suffer from design faults and poor constructional workmanship. (This will be pursued in Part 4) In recent years we have developed work planning systems which have greatly increased the staff levels at the foreman and engineer grades and taking initiative and decision making from the industrial staff. The low rates of pay have probably led to matching standard of industrial staff. Our power stations have a substantial number of engineers to investigate problems which are then planned and programmed by the foreman and carried out by the industrial staff at low rates of productivity. Since our engineers are mostly technicians and are more numerous than the industrial staff in American stations they could adequately carry out the work required with very little additional support. The recognition of the average engineer's true status by the creation of technician grades would be the most effective single organizational change in C.E.G.B. power stations likely to give organizational effectiveness commensurate with that of the French and American stations studied.

CHAPTER 7

REGULATING ACTIVITIES

Introduction

The first requirement is to establish how this chapter should be presented. Regulating activities broadly divide into technical and non technical types and my studies divide into C E.G.B. and overseas power stations. In the case of the core and maintenance activities the technology ensured that the same pattern was followed in all power stations, but the activities covered in this chapter have given rise to some substantial organizational differences. For example, in the three American stations studied the average number of staff in these activities was 31 and the C.E.G B. figure was eight times higher at 245.

Some of the differences might be accounted for by considering an analogy with physics. Sir Isaac Newton (1687) in his Principia enunciated the laws of motion the first of which was "all bodies continue in their state of rest or of uniform motion in a straight line unless they are compelled to change that state by external forces". A fully commissioned power station in many ways is analogous to a body in a state of uniform motion and the power generating authorities desire nothing more than that their power stations should continue in such a steady state until the end of their working lives. I will try to show that many of the regulatory activities in C.E.G.B. stations started out as forces for change and might be preventing a steady state condition from being reached.

I will review the regulatory activities in the overseas stations first and these will provide a framework against which the C.E.G.B. activities can be referred. In the final section I shall make some of the more important comparisons.

Regulatory activities in overseas power stations

The picture of the station superintendent's job was limited but at the Marshall plant I judged that a close rapport existed between the station superintendent and the rest of the station staff. This seemed to be apparent from the informal and casual discussions he held with various staff members at all levels together with the easy informal manner of their replies. He told me that all station superintendents had an involvement in the Duke Power Company's policy formulation and attended headquarters meetings from time to time. He was evidently the "outside" man for the station, appeared to exercise a reasonable degree of autonomy and worked closely with his departmental heads.

At the T.V.A. power stations the station superintendents duties were shared with the deputy and at Bull Run I was told that the style of station management varied considerably and some of the "old style" station superintendents were very authoritarian in their approach. Station superintendents were at liberty to make changes to their organizational structure within certain limits but most such changes were made in consultation with the headquarters.

At Bull Run the administration department comprised a total of seven staff two of whom dealt with the payroll including returns to headquarters of hours worked, overtime hours and premium hours. Another kept a record of all the fuel transactions for the station and the remainder covered general duties including receptionist, telephonist, private secretary and secretarial services for departmental heads. Very similar arrangements existed at the Marshall and Sequoyah plants. The security staff at all the stations were minimal and were seconded headquarter's staff for the T.V.A. stations but contract staff for the Marshall plant. Cleaning staff at Marshall plant were on contract; those at Bull Run were directed by the operations superintendent and those at Sequoyah were the responsibility of the administration department. At Bull Run there was a safety engineer and at Sequoyah a headquarter's nursé was in attendance.

Planning at Marshall plant was the responsibility of two engineers within the maintenance department. Their work was concerned with the long term plan including the preparation of work schedules for outages. Headquarter's requests were slotted into the planning programme together with any outstanding jobs from the normal routine maintenance. The work planning for outages involved close co-operation with the headquarter's groups who provided the maintenance crews. At Bull Run station an engineering assistant in the maintenance department carried out the planning function including the organizing of supplies and the keeping of maintenance records. Work lists for the different trades were compiled before outages and these indicated the work priorities. These lists could be hurriedly prepared to cope with unplanned outages and provided a very flexible planning system which was coupled to the flexible workforce making use of the dual facilities of substantial overtime and short term hired labour.

At Marshall plant there were five engineers classed as the day operations group and they provided a mixed range of services including availability for normal operations duty as cover for absences. They also carried out checks on plant safety systems and assisted planning by co-ordinating isolation requirements for outages. The two more senior members of this group dealt with personnel problems for the whole of the staff.

The technical regulatory functions at these stations were test and efficiency and chemistry. The chemistry section at Bull Run and Marshall concentrated on coal, water and ash samples. Neither laboratory was equipped to carry out unusual or difficult chemical analyses outside the normal routine. Samples were sent to all stations by headquarter's laboratories in order to check that correct standards were being maintained. At Bull Run power station a high level of automation was employed,with water samples from all parts of the plant being drip fed into an automatic analyser.

The test and efficiency group at Bull Run carried out tests on different time cycles ranging from annual to daily. The test and efficiency engineer analysed operating data and assessed performance on a long term comparative basis. From these operating statistics the departmental head prepared reports for headquarters giving reasons for plant deviations. At Marshall plant three engineers carried out test and efficiency functions. The more senior engineer analysed the results from routine tests and carried out special tests on plant items. One of the junior engineers assisted in the routine testing and carried out checks to improve plant performance. The other junior engineer carried out various minor improvement projects on the plant.

From the information reported about the River Rouge plant the activities appeared to be essentially similar to those on the other American stations with the exception that a canteen service was provided. None of the three stations I visited had any canteen facilities except the provision of vending machines and a few tables and chairs. This provision was in accordance with Federal law which also stipulated that the franchise for such vending machines had to be offered to any disabled persons living in the vicinity. The machines at Sequoyah were serviced by a blind person. The common practice in American stations is for staff of all grades to start at 8 o'clock and to bring sandwiches for a short lunch break generally taken in the office. (Recently the staff at Fossil Strand voted in favour of a reduced lunch break and an earlier finish to the day). I was told that a microwave oven and meals were available for the shift staff in the American stations.

Detailed information on the French power stations was not available but many of the technical regulatory activities were carried out by the operations shift staff when working their sixth shift cycle on days. There were one or two permanent technical controllers in charge of the facility. At Martigues seven persons dealt with method study, planning, plant history and technical drawings. A further six staff performed administrative functions similar to those at the American stations. The station also had a nurse and a safety office. At the St Laurent nuclear station there were ten in the administration department and eleven dealing with safety and site security. A calculation and statistics group produced station performance data. From the numbers of staff involved it would seem as if the general pattern of regulatory activities in French stations followed closely the lines of the American stations. Before analysing the C.E.G B. stations it might be useful to display the totals of regulatory staff.

TABLE 10 REGULATING STAFF TOTALS

Station	Total Staff
Marshall	32
Bull Run	29
Sequoyah	32
Ash Haven	344
Fossil Strand	271
Downton	164
Olliton Reach	201

Regulatory activities in C.E.G B. stations

The range of these functions in the C.E.G.B. stations studied varied considerably but Ash Haven covered the whole range (except reactor physics) and, furthermore, they were all studied in some depth at this station. I think it will be easier for the reader if I deal with each activity separately using Ash Haven as a focus. All the activities are shown in the organizational chart (figure 8). I will start the analysis with the technical regulating functions since these are similar to the equivalent functions in American stations.

Test and Efficiency Sections

At Ash Haven this group comprised six engineers divided into sub-groups for each station as shown in figure 9.

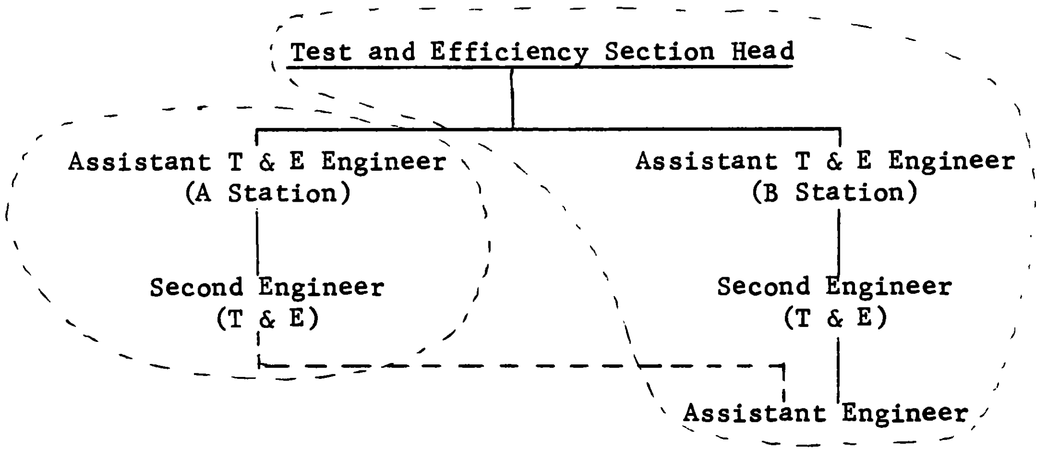


FIGURE 9 ASH HAVEN TEST AND EFFICIENCY SECTION

The primary purpose is to take measurements on the physical state of the plant conditions and maintenance engineers can have data for guidance on the timings and extent of work.

The Ash Haven section head had his office in the 'B' station and was therefore a member of that sub-group. The other engineers within the group changed stations on an annual basis. The two assistant test and efficiency engineers had the primary responsibility for analysing the results of tests and measurements on their stations and for producing the data in standard forms. In addition to these routines a considerable number of "ad hoc" tests were carried out which could be described as semi-routine and from which, graphs, statistics and diagrams were prepared. The measurements for such tests were either done by the assistant test and efficiency engineer or the second engineer. The section had a total workload in excess of the work capacity of the engineers. They thus had to choose the more important jobs from all those needing to be done. This pressure of work was exacerbated by the fact that occasionally a second engineer would be seconded to other duties.

Despite these pressures the section head spent half his time on administrative matters, or discussions about test requirements with engineers. The remainder of his time was spent on the plant carrying out investigations or making decisions about the appropriateness of tests or the procedures to be followed. The two assistant test and efficiency engineers spent about half their time in their offices much of it on the analysis of charts, printouts etc. and the interpretating data. Some of this time was spent on administrative work, the other half was spent on the plant taking measurements or organizing tests. The second engineers spent three-quarters of their time on the plant making preparations for measurements or taking readings etc. For major series of measurements requiring concurrent sets of readings all the section engineers would work together probably for a couple of days to complete them.

At Olliton Reach Power Station the test and efficiency section additionally provided maintenance type services by making the necessary plant adjustments after taking measurements. A small workforce of industrial staff performed other maintenance tasks such as lubrication and oil burner cleaning. This group was interesting since it was largely self monitoring and took a pride in ensure that the burners were always at optimum efficiency. I was told that this group spotted and reported far more plant faults than any other similar size group on the station. The assistant efficiency engineer directed this group and checked and assessed data produced by the second engineers. He also carried out plant vibration monitoring and took the role of group leader for team investigations. A note on vibration monitoring might be appropriate; measuring equipment is temporary attached to rotating machinery and the vibration patterns measured which give a trained operator a reasonable indication of the state of the bearings. With proper knowledge of the plant it is possible to optimize the maintenance periods by such techniques. By comparison, bearing temperature measurements are a crude indicator and effective only just prior to plant breakdown.

At Fossil Strand Power Station each of the operations departments had a small test and efficiency section which prepared the required statistics for headquarters purposes. Most of the work was routine and two groups of three engineers carried it out.

At Downton Power Station the test and efficiency group carried out analyses similar to those at Olliton together with vibration monitoring. The test and efficiency engineer performed probability calculations to determine frequency of maintenance etc.

In summarising the test and efficiency groups at the four stations studied some interesting variations emerge. At Ash Haven, a great deal of routine T & E work was not done because the staff were deployed on measurements to optimise the re-commissioning of the plant. At Olliton, in addition to extensive checks and measurements on all the station plant to provide data for optimising operations and maintenance work, they also carried out some routine maintenance on the plant. This reflected the lack of co-operation between operations and maintenance which existed at that station, an example of which was given in Chapter 5. The operations superintendent said that both operations and maintenance staff respected the test and efficiency group and regarded them as neutral. At Downton the information obtained was additionally used for management policy formulation and the unit made extensive use of the computer facility. At Fossil Strand substantial groups of specialist engineers existed in the day operations branch and therefore test and efficiency section was reduced to producing the routine returns required.

One thing the test and efficiency engineers seemed to share in common was the spending of a high proportion of their time on actually taking or analysing measurements. These percentages were calculated for all the engineers at Olliton Reach Power Station and gave an average value for test and efficiency engineers of approximately two-thirds of time. If allowance is made for the fact that the section head (like most other section heads) spent a majority of his time at meetings and in discussions or dealing with administrative matters then the figure for the working engineers becomes three-quarters. In three of the stations, functions additional to the test and efficiency were carried out. Two of these sets of functions could be described as processes for organizational change.

The Chemistry Branch

The chemistry group at Ash Haven and at all the other stations, was close-knit with a strong sense of group cohesiveness. Chemists are normally not employed elsewhere in power stations and generally represent the only scientific discipline on the site. The sense of belonging within the section was supplemented by the additional tie of professionalism. There were sub-divisions within the group and these are shown in figure 10.

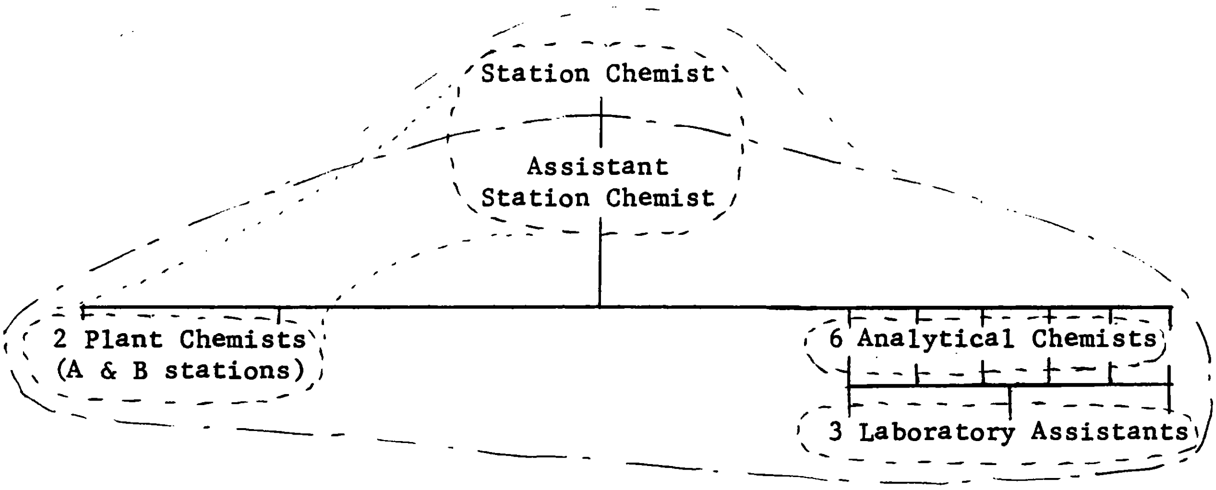


FIGURE 10 ASH HAVEN CHEMISTRY BRANCH

The group structure was accentuated by a sharing of duties. Policy and Branch Management were shared by the station chemist and his assistant, the station chemist acting as outside man and the assistant dealing with day to day running of the branch. Next in seniority were the two plant chemists who provided technical chemical advice to the two stations based on chemical analyses. They also participated in branch policy from time to time and changed stations on a six monthly basis. Giving advice occupied about half their time and the other half was spent carrying out analyses. The six analytical chemists carried out six different sets of analyses and changed jobs each month. About 80% of their time was spent on analyses, the remainder on reporting work etc. The routine analyses (mainly coal and water) were carried out by the three lab. technicians under the supervision of the analytical chemists. Each of the groups formed a social sub-group as shown sharing meal-breaks etc. The chemistry branch as a whole had occasional social activities outside work. Subsidiary duties provided by the chemistry branch include photography.

At Olliton Power Station it was considered necessary to have some chemistry assistants on shift mainly for water analyses whereas Ash Haven found no such need even though similar operating conditions prevailed. Downton Power Station operated with a much smaller total staff (total of seven) and also provided services such as photography. Fossil Strand also operated with a smaller branch and provided shift chemists.

Reactor Physics

At Fossil Strand an additional group came within the category of regulatory functions and this was the reactor physics department. It was responsible for advising on reactor conditions and giving instructions to operations about the loading of fuel. A proportion of the department's work was routine e.g. the monitoring of reactor conditions and temperatures, but the remainder was of a development or advisory nature particularly when the new station had been commissioned.

Fourteen engineers at different grades comprised the department and the pattern of work was such as to avoid compartmentalization as much as possible. Routine tasks were allocated to individuals for a limited period of time. Technical problems were undertaken by individual engineers who would investigate and generally talk the problem out with colleagues. A certain number of measurements could be taken on the plant but much of the work was statistical and analytical and carried out in the office. The total organization of the department was of a fluid nature without clearly defined positions other than those of the departmental head and his deputy. Both these individuals were fully immersed in the departments problems and their role was more that of leader than boss. The whole departmental structure had much in common with the organic type as outlined by Burns and Stalker (1961) during their study of research organizations.

Site services

As mentioned at the beginning of Chapter 5 the activities collectively comprising the site services partly belong to system maintenance and partly to the regulating group. At Ash Haven they all came under the control of one engineer and only one of the services (boiler cleaning) was directly concerned with the main plant. Because it would be messy to spread the group across two chapters I shall treat them as an entity.

The engineer in charge was the site transport manager (a statutory requirement). Six separate functions are each performed by a group and the total staff numbered 174, the majority of which were unskilled labourers. Each of the groups had at least two foremen but half of these had duties in the works office.

A transport group comprised ten fitters and two mates and they maintained the 75 vehicles on the site. In the building maintenance team there were twenty tradesmen but large maintenance jobs were carried out by contractors.

The station warden (roughly equivalent to a foreman) had responsibility for the five drivers whose duties varied from forklifting a couple of drums off a lorry to carrying out long distance trips for the collection of goods. The bulk of their work was short term jobs about the site which typically lasted 10 minutes. This group was interesting because even this station had virtually given up the attempt to carry out short term planning in relation to these duties. The drivers were each given a series of "official" jobs to last the day but which actually took only a fraction of the time allowed. All minor jobs were then fitted into the free time. The point of interest is that this group instead of using the free time for scrounging (as did most the other groups on the site with free time) the drivers took a great pride in providing an effective and rapid delivery service to their "customers" on the site.

The other group under the direction of the station warden were the security guards comprising twelve men divided into four teams. The three sets of duties were shared informally and with all the electronic surveillance and anti-terrorist equipment installed their job was much more technically demanding than the traditional job of a night watchman.

The twenty-four boiler cleaners provided seven day cover and their main duty was to go inside the boilers as soon as possible to remove the large quantities of dust and carry out descaling. This was always the first stage of any boiler maintenance work. When all the boilers were on load they spent their time cleaning the outsides of boilers or acting as fitter's mates. About two-thirds of their work was internal boiler cleaning and one-third external. The work of this group was also subject to the productivity scheme which had lowered their effectiveness. The group use to take a pride in getting the boilers clean in the shortest possible time by working extremely hard for brief periods whilst the boilers were still very hot and then coming out for a breather. The productivity scheme destroyed this attitude and the men no longer worked extremely hard nor did they overtly take breaks.

The largest group in the site services were the labourers and cleaners and for many this was a transitory post on route for A.P.A. or fitters mate jobs. For others the positions were permanent and for yet another sub group who had no intention of staying permanently on the station the work was treated as casual labour. The "permanent" cleaners were each allocated certain rooms or amenity buildings and generally took a pride in their state. The permanent labourers were regarded as valuable"odd job" men and took a pride in providing specialist services in much the same way as did the drivers. The remainders of the labourers and cleaners led a "grey" type of existence moving round in gangs from one clearing up job to the next. Sharp divisions existed within the group between those who intended to make a career in the station and the "casuals" who were regarded by the former as scroungers. This division had characteristics similar to those found in the Hawthorn bank wiring teams.

At Fossil Strand the site services came under the direction of the station warden who had the status of section head within the administrative department. At both Downton and Olliton stations the boiler cleaners were deployed as a part of the shift maintenance team which logically would seem to be the best place for them. Building maintenance and transport at Downton were under the control of a services engineer whereas at Olliton a similar situation existed but the engineer's title was buildings engineer. One difference at Olliton was the use of contractors for security and for cleaning. As far as Regional headquarter's were concerned these staff (together with the canteen staff) did not exist as part of the station manpower.

Station management

Patterns of management in power stations were studied in some depth in my earlier dissertation (Johnston 1973) and an indication of the station management styles was given in Part 1 of this thesis.

At Ash Haven the management team comprised six departmental heads plus the station manager and his deputy. The two departmental heads associated with improvement tasks were not so closely involved with day to day management problems as the remainder, but even the remaining departmental heads felt left out of policy formulation to some extent, this being the prerogative of the station manager and his deputy. Thus a substantial gap was seen to exist between the top management group and the departmental heads. A similar gap existed at Fossil Strand Power Station but has been diminished by the new station manager.

A substantial proportion of station manager's time is still spent off-site, the value being over one third for the Olliton station manager. Part of the problem arises from the system of group managers who have line responsibility for the power stations within their group. Each group comprises five power stations, two of which are of major significance and absorb much of the effort of the group managers. The group managers monitor, check and question the performance of the stations and can draw on the resources of the regional headquarters about three-quarters of whose effort is in the nature of monitoring activities in relation to the region's stations. Many of the regional services are structured to provide one member of staff for each group manager's block of stations.

In the station the deputy station manager normally carries responsibility for the day to day running of the plant and the co-ordination of operations and maintenance. This tends to put the station manager in the role of a buffer between the regional headquarters monitoring activities spearheaded by a group manager and a defensive power station with the station manager at the boundary.

A natural tendency exists for regional staff to provide comparative data on the performance of the various stations within the Region. Additionally, London headquarters sometimes asks for data on a regional comparative basis. Such monitoring tends to pick on the poor performance factors of a particular power station and might ignore the counterbalancing factors. One such pair of matching factors are plant efficiency and plant availability. Normally, if a station is to maximise plant availability then the efficiency will suffer. The converse is also true. One rather cynical manager said that it was almost possible to predict six months ahead what the next subject for attack would be arising from the current pressure applied by R.H.Q. and the group manager. It is interesting to note that although this station manager was at the receiving end of autocratic management he practiced a similar style himself. At formal meetings he would go through the agenda, item by item and would unerringly pounce on those items where problems existed. A departmental head who had studied his technique said the station manager relied on the "feel" of the meeting as well as the context of the agenda. Another practice of this manager was to "pick off" any opposition one by one but the departmental heads countered this behaviour by holding a series of pre-meeting telephone calls to get prior agreement on those items where they would jointly dig in and resist the station manager. Despite the autocratic style at this station the management team remained close knit because of the tight social links at work e.g. always lunching together.

The effects of the management on the total station staff was assessed at Ash Haven Power Station. The present station manager was considered to be remote and the majority of staff at all levels (including departmental heads) disliked or resented this. Many of the staff had served under the previous paternalistic station manager who was renown for probing into events on the station but also tried to know every man on the site.

Returning to the pattern of work for the senior management the operations superintendent at Ash Haven station considered his time was spent as follows:-

Dealing with industrial relations	25%
Co-ordinating the 'A' station production problems	15%
Dealing with budgets	5%
Considering and making decisions on technical problems	10%
Holding interviews, staff training and authorisation meetings	10%
Reading and preparing various reports	30%
Dealing with environmental matters	5%

It was generally the case that departmental heads worked in excess of the normal hours and station managers work considerably in excess. A figure of about ten to twelve hours a week would be normal.

The administration services

The basic framework for the administration structure in all the C.E.G.B. power stations was as shown in figure 11.

Station Manager

Station Administrative Officer
(S.A.O.)

Technical Services | Stores | Finance | Personnel & Salaries | Office Services

FIGURE 11 ADMINISTRATION SERVICES FRAMEWORK

During my research the most thorough study of the administrative functions was carried out at Downton station and its administration department will be used as the basis for this section of the report. There were some variations in the organization at the other stations studied, for example, at Ash Haven the general administrative services were shared between five other sections.

The Station Administrative Officer At Downton the S.A.O. delegated all routine work and responsibility to the section heads. As a member of the management team he was frequently involved in meetings and discussions with other senior staff. His areas of expertise were generally in the fields of law or public relations and he advised on industrial relations procedures. Another task was dealing with departmental matters including monitoring work, preparing budgets and discussing procedures. The S.A.O. would normally be expected to deal with outside enquiries which were not technical in nature. In practice, much of the work of the S.A.O. was taken up with routine checking of work by discussing matters before signing letters and dealing with problems passed on by the station manager. At some of the stations the S.A.O. was responsible directly to the station manager (as shown in figure 11) but at others he came below the deputy station manager in the organizational structure.

Technical services This section was sub-divided into the works office and the technical records. The works office clerical service comprised a team of five clerks led by a senior clerk. All the work order cards were sorted and registers prepared. Hours worked by each fitter were entered on summary sheets and totals for the productivity scheme prepared. Incomplete cards were queried and information filed on the plant history records. The senior clerk supervised this work and spent a considerable amount of time cost-coding defect cards and dealing with enquiries from engineers. The team formed part of the works office group together with planning engineers and foremen. The volume of work was substantial and the practice was to rotate jobs on a weekly basis.

The section head was closely involved with the technical records, and was often required to present data in alternative forms. Many of the calculations were carried out by the senior technical records clerk in the form of routine returns on a daily, weekly and monthly basis to R.H.Q. An information room was also maintained at the station where technical data relating to the plant was continuously displayed and updated. The V.D.U. (visual display unit) operator made use of regional computer programmes by feeding statistical data in and interpreting the output. Another function was the conversion of the work order cards into computer printouts.

Stores section The main function of the stores was to provide a materials service and this has been discussed in the previous chapter. The remainder of the stores group carry out administrative functions associated with stores purchasing and records. The stores section head spent most of his time in dealing with problems, procuring goods or in discussions with engineers on stockholding levels. A senior clerk had special responsibility for the purchasing aspects and with two other clerks wrote orders, updated stores catalogues and dealt with enquiries. Another senior clerk was engaged in progressing orders and building-up information relating to suppliers for advising engineers on the availability of goods and services. Other routine stores duties were sorting and compiling of issue notes, receipt notes and keeping stock records.

The Finance section The finance section was reponsible for the clerical supervision of station budgets, keeping financial records and checking the accounts including fuel payments. The section head generally monitored the work of the section and provided advice and guidance on finance to the management team and to other station staff. He dealt with more important non-routine problems and made decisions. A senior clerk monitored capital and revenue expenditure against budgets and followed up any variances: future commitments were checked against the budget: preparation of the annual budgets was also his responsibility. The cashier had the duty of collecting and making all cash payment on behalf of the station and keeping accurate records of the transactions; weekly pay packets were made up and expenses, restaurant takings and sports and social club monies were handled. Another clerk kept a record of fuel deliveries and investigated anomalies or shortfalls, invoices were checked and returns made to headquarters. These tasks occupied about two-thirds of time,the remainder being spent allocating cost codes to stores issue notes. Two junior clerks assisted with these duties and the cash clerk assisted with making up pay packets and servicing vending machines. The accounts clerk checked rail-wagon weights against the advised weights, check ash sales tickets and oil tanker deliveries. The remaining time of these clerks was spent on various duties.

The finance section also monitored contracts. This comprised the preparation of contract specifications using basic data and technical requirements provided by engineers. The object was to achieve uniformity of specifications with no loopholes. This clerk also monitored contracts in progress by checking contractors time-sheets; ensuring that engineers were satisfied with the work and checking invoices before authorising payment.

Personnel & Salaries section The main tasks of this section were the preparation of the weekly payroll and the updating of personnel records. The section had monitored the work and was involved in all aspects. All confidential matters and many non-routine matters were dealt with by the section head and certain parts of the work (e.g. the payroll) had to be double checked. The senior clerk supervised day to day business and dealt with administrative matters relating to vacancies, appointments, advertisements and induction procedures. Three junior clerks were occupied in the preparation of data for the payroll such as checking weekly work sheets and entering any special payments due. Keeping sickness records and preparing staff statistics were other duties. The data for the pay and productivity calculations, sickness and holiday records were also kept within the section. Requests for holiday and pay advances were dealt with and statistical returns prepared for R.H.Q.

Office Services At this station office services did not have a section head, a senior clerk managed the facility reporting directly to the S.A.O. The services included typing, reception, telephone and the registry. The senior clerk dealt with the post, wrote station procedures and reference books, kept accident records and supervised the stationery store. New recruits generally entered this section and were given administrative training by the senior clerk. Two junior clerks dealt with routine work such as filing, coding the mail and providing a copying service for the station. These two clerks also provided a stand-in service for other staff such as the telephonist. The telephonist/receptionist was occupied with those duties for most of the day but carried out copy typing during slack periods. The shorthand typist provided secretarial services for the departmental heads and carried out typing for any other staff. She also was relief for the station manager's private secretary. All confidential files were kept by the private secretary. One additional typist mostly carried out copy typing and was available for standby duties as V.D.U. operator or telephonist.

The restaurant At Downton the dining facility was called a restaurant and endeavoured to set commensurate standards. The manageress had responsibility for all aspects including industrial relations and dealing with staff problems. In addition to generally managing and programming the work she cooked any special meals required. The remaining staff comprised two cooks and seven attendants who shared the duties on a rota basis.

General Downton administration department comprised thirty-seven N.J C. staff, the figure for Olliton being thirty-six, but account has to be taken of the contractors who staffed the canteen. At Fossil Strand the staff numbered seventy-one and at Ash Haven the figure was sixty-six. The latter stations were both dual-site and for much of the work, the workload was proportional to the total site staff. (e.g. payroll, stores issues)

Certain of the procedures were responsible for the much higher staff levels for administration in C.E.G.B. power stations. Variations, additions and subtractions to pay numbered over one hundred, a typical example being A.C.M. (abnormal conditions money) payments which often amounted to a few pence per hour and had to be calculated for the payroll. Furthermore, the more complications that were introduced into the pay, the greater was the number of queries arising. One salaries section head acknowledged that it was impossible for industrial staff to be able to determine their net pay from the information given on the payslip. The other areas involving substantial numbers of clerical staff were the short term planning system, the productivity bonus payment scheme and the stores control systems. (The purchasing and payments procedures were split between the station and R.H.Q)

Another source of work for the administration department and particularly for the S.A.O. was the demand for information arising from systems operated at R.H.Q. and the information to satisfy the Health & Safety at Work Act. Station managers attend a great many meetings at headquarters and for all of these they have to be briefed by the station. Headquarters will similarly brief the group managers and invariably the data do not agree. This subsequently involves considerable effort on the part of station administration, usually by section heads and senior clerks. These are some of the ways in which the high levels of administration staffing can be accounted for.

<u>The planning system</u>

In the C.E.G.B. power stations the planning system is used as a form of communication and permeates almost the whole of the organization. At this stage it will be useful to outline the basic systems used in order that this interaction can be better understood. The system is an amalgamation of five separate functions:-

1. Long Term Planning
2. Short Term Planning
3. Contingency Planning

4. Work Study
5. The Productivity Scheme

Plant history records are also associated with the planning function.

Some aspects of power station planning have to be considered on a regional or even national basis, a good example being the programming of turbine rotor maintenance through the manufacturers works or the C.E.G.B. national facilities. A national monitoring function associated with planning is the plant inspection and testing board (P.I T B.) which placed engineers at major manufacturing locations to inspect all work in progress on behalf of the C.E.G.B. I was given examples of how this theoretically admirable system failed in practice due to the permanently stationed Board's employee developing loyalties to the company to whom he was attached. No form of corruption or dishonesty was involved but the planning programme was sometimes allowed to slip. The only other direct involvement in planning of the regional or national organization is to ensure that the overhaul programme allows sufficient plant to be available during the summer period. Whilst small stations still exist the tendency is to take the 500 MW units out of service in summer and provide cover with smaller sets. At sometime in the future a different working pattern will be necessary as the older stations are phased out. Most outages on 500 MW units involve a period of seven or eight weeks but with modifications this is sometimes as long as thirteen weeks. The five major stations in the region have seventeen large units in total and regional planning will try to ensure that only two are under maintenance at any time.

Long term planning Under this system preparations for outages are made as long as five years ahead. The elements and stages of the process are as follows:-

1. Broad outline planning by station management and senior engineers. From this a main planning network is prepared by the planning engineer and checks made with outside organizations likely to be involved and with R.H.Q.

2. If required, alternatives are considered such as programming blocks of the work as minor outages and thereby reducing the overall major outage time. Such alternative plans would be produced by the long term planning engineer.

3. Critical path networks are prepared for blocks of work which are contiguous, an example would be the stages involved in dismantling a turbine. The long term planning engineer builds up this information from previous planning programmes supplemented by additional knowledge and experience.

4. To the basic planning framework which emerges, other units of work are added such as items requiring an outage but not normally a part of one. These planning networks are built up as a computer programme and use is made of the headquarters computer facility. At all stages checks are made with station's engineers, outside suppliers etc.

5. Co-ordinating and estimating the resources required for the outage and ensuring that the appropriate action is taken to procure them e.g. the placing of contracts. Quite often such contracts will need to be placed a considerable time ahead.

6. The co-ordinating and checking of progress increases in order to eliminate any delays and avoid any hold-ups.

7. The programme is finally handed-over for implementation which is carried out by the short term planning staff but usually under the direction of a project engineer who was nominated for the outage.

The other involvement of the long term planning engineers is with major forms of contingency planning. Examples are plant defects requiring an outage for their repair and needing fairly urgent attention either because they are steadily worsening or because they adversely effect plant output. For high merit plant it is usual to plan a weekend outage for such work and a suitable programme would be prepared by the long term planning engineers. (There is normally less demand for generating plant at weekends.)

There is an equivalent to defect maintenance associated with long term planning; very often additional work will be discovered when units of plant are opened up and such work has to be incorporated in much the same way as defects are incorporated into the normal short term planning.

Short term planning Is concerned with the daily work programme. Some reviewing of work up to three weeks ahead takes place as this is the timescale of concern to station management and it enables branch managers to plan their short term requirements with the knowledge that they will have certain other commitments. The main stages in short term planning are as follows:-

1. Preparing and automatically producing a preventative maintenance schedule which sets out units of work in a routine manner.

2. These go as a weekly programme to each maintenance engineer who decides whether they will be carried out. (e.g. a recently repaired defect might cancel the need for routine work.)

3. Defect requirements are slotted into the current work programme as soon as they arise.

4. The total work programme is allocated in accordance with the manpower resources available and inter-related work is co-ordinated.

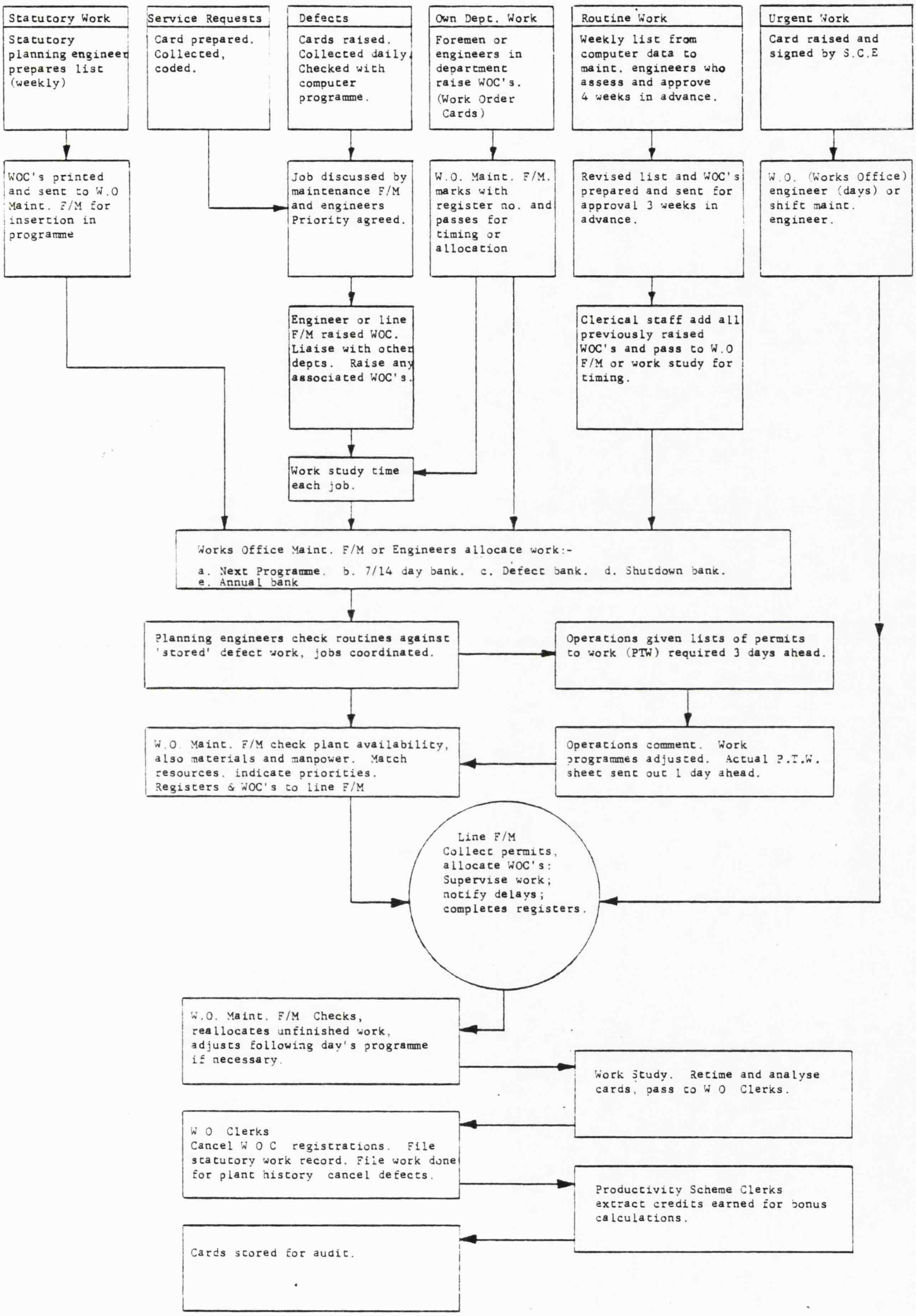
5. Materials availability and permits to work are checked and allocated to the work.

6. The completed work is recorded for plant history purposes.

The basis of the system is the work order card which specifies a certain job of work to be carried out on an item of equipment by an individual defined in terms of skill. It contains information about how the job should be done, how long it should take and what equipment will be required. In some stations the individuals are named by the works office but in others the line foreman has some discretion in this respect. The work order cards originate from six different sources and a brief outline of the scheme is given in figure 12. It is called a simplified work planning procedure and contains twenty-five stages. The actual planning procedure contains about one hundred and fifty different steps and most of the paperwork prepared is either in triplicate or quadruplicate. All copies are checked at various intervals and cross-checked on completion before destruction.

It was said at the beginning of this section that the planning system involved nearly everyone on the station. This statement mostly applied to the short term planning system and the level of involvement increases as one progresses down the organizational chart. Senior station management is normally involved only at weekly intervals but departmental and branch heads get drawn in on a daily basis. With the exception of those engineers engaged in plant improvement work, it would be fair to say that engineers can only get work done through the work planning procedure. All the foremen are heavily involved and at stations like Ash Haven they spend half their time in the planning office. All the work of industrial staff is "officially" carried out through the system. The system also includes clerical staff in the planning office and, to a lesser extent, in the stores section. Other administrative departments e.g. personnel and salaries are indirectly affected.

The system serves as a formal communication network by means of which the work requirements of the various levels of management are communicated to the workforce who perform them. The impersonal nature of the communication (timed instruction card) was the underlying cause



SIMPLIFIED WORK PLANNING PROCEDURE FIGURE 12 of much discontent according to the comments made by the staff. For example, if the work study engineer is to allocate a fair time to a maintenance job he must be given sufficient information about the work content. This requires a foreman to write-out a detailed work specification including all the stages. When low times are given the foreman tends to sympathise with the fitter and blame the work study assistants even though it might indirectly be his fault. Not surprisingly, the work study assistants at one station studied were one of the most unhappy and discontented groups on the site.

The works office duties of the foremen associated with short term planning can be gathered from figure 12. In practice they maintain informal contacts with the line foremen, monitor progress of work during the day and exercise discretion about the work to be dropped when additional work comes in. The planning engineers are concerned with work co-ordination and decision making about blocks of work. At most of the stations studied the planning engineers spent half their time at meetings. Seven day working was usually practiced for planning engineers on a one in four weekend basis. At Ash Haven the level of defect maintenance was much higher than at the other stations and this placed a tremendous strain on the short term planning system. The engineers and foremen in the office spent over half their time on the telephone cancelling, correcting or cajoling as work priorities continuously changed. As one graduate engineer said, "this job has got nothing to do with engineering, but it's like Clapham Junction here and the 'busyness' takes your mind off the futility of it all". Most other stations were spared the excess of defect problems besetting Ash Haven and the more that short term work is preplanned the more reasonable it becomes. However, at Fossil Strand, about half the work was of a defect nature and several of the maintenance engineers said that actually organizing work was a short circuiting procedure which mostly took place outside the formal planning system.

Before the short term planning system most maintenance engineers operated preventative maintenance schedules similar to those described for the U.S. power stations. The feedback of information from such systems was direct and schedules would be adjusted until, over a period of a few years, some optimization was achieved. Such optimization was being pursued as management policy at two of the stations in this study (Downton and Olliton). Also, under the old system, defects were primarily of interest to operations and maintenance staff. Engineers would assess a problem, make a decision and operations would isolate the plant. This is the system used in U.S. power stations where it is a matter of station policy to attend to all defects on the same day. It is also the policy of shift maintenance teams and a "blind eye" is often turned when they carry out work not strictly of an urgent nature. In the U.S. power stations the formal planning system (job cards etc.) existed in an attenuated form but was only used if the workload got out of hand in the short term. This was the essential difference between the two systems.

The pay and productivity scheme The procedures came into being because of the introduction of this scheme which required all work to be measured and timed. The intention was to increase the then low productivity but the general opinion is that effective productivity has been reduced since the introduction of the scheme. It is estimated that the men's productivity has increased from around 40% to about 50%. But in order to ensure that adequate credits could be earned a great deal of work had to be "invented" for the scheme to become viable. Initially there was some reduction in staff but this was offset by considerable increases in engineering, supervisory and administrative staff. The Board's statistics show a reduction in staff per megawatt of plant and this is credited to the scheme. But this took place during the commissioning period of nearly all the large 500 MW units and the closure of many small stations. Measurements taken at Fossil Strand and Ash Haven indicate increases in staff on some plant areas for the same work output. In other cases standards have deteriorated or contractors now carry out some work. A Board member (Fenton 1973) stated that the scheme deliberately avoided piecework incentive approaches and encouraged individuals to work consistently to avoid jeopardizing their own or their colleagues bonuses. It was also said that lines of demarcation between trades were being broken down.

According to repeatedly expressed opinions at Ash Haven and Fossil Strand these statements were not correct and the scheme had detracted from co-operative or group working since each individual was required to earn eight credits per day. This requirement put another interpretation onto different types of jobs since some are "open ended" e.g. cleaning and others are "closed" e.g. dismantle, repair and re-assemble. Closed work was mostly associated with plant maintenance and as a result these staff did worst under the scheme because measured times were often inadequate to cover particular difficulties associated with an item of plant. Operations staff had a great many fill-in (open) jobs, because an important part of their work is to be available when plant conditions change. This inherent variability of the work pressure associated with operating power station plant is probably a major reason for the schemes failure. Other important criticisms were that work priorities were now decided too remotely and that planners tended to leave the jobs which were difficult to plan but which might be the most urgently required. The scheme replaced individual responsibility by systems and programmes with the loss of flexibility provided by human brain-power at all levels in the organization. Also, it often led to a reversal of "rewards": for example, a job with an easy time might be quickly finished by an individual who could then scrounge but would still satisfy the foreman (i.e. the system). Another individual might be deeply involved in the job, turn out first-class work, but overrun his time. Instead of getting thanks, the foreman would tend to be displeased. Many examples quoted in previous chapters indicated that where the system was not operated, greater commitment to work and a higher work output appeared to be the outcome. It was also pointed out that if the plant was put into first-class condition there would be insufficient work to support the full bonus. Therefore the scheme would lead to a conflict of interest between the management and industrial staff.

The scheme led to delays which often caused further work. One engineer at Ash Haven described how the organization functioned in practice. He took as an example a small leak such as a valve gland. He assumed that the A.P.A. discovering the leak told the unit operator who then had a look and told the second engineer who also had a look and then wrote a defect report. The report then went through the planning system and to the craft foreman who investigated and wrote a work order card. Planning received the work order card and wrote a permit request which went to the second engineer who told the foreman who told the A.P.A. to lock the item off. The foreman then checked the isolation and the second engineer rechecked it before signing the permit. The maintenance foreman would then collect the permit and work order card and the fitter would fix the leak. He would then tell his foreman to cancel the permit which went to the second engineer in operations who told the foreman who told the A.P.A. to clear the isolation. The second engineer then cleared the permit.

The system is used for serious leaks but also for gland leaks and cold water supply leaks etc. Very often, by the time the fitter is actually fixing the leak it has progressed to the point where more serious damage has been done to the equipment which then needs renewing. In such cases the fitter would report the condition and the job would be re-cycled through the system once again. The engineers said that before the systems were introduced many such leaks were fixed by operating staff. It is also easy to see why shift maintenance staff can operate far more flexibly and why many jobs are performed "unofficially" by shift teams. The main reason for the introduction of the system was the need to time work for the productivity scheme.

Probably the most remarkable thing about the short term planning system of the C.E.G B. is the fact that so few staff are required to identify, report, describe, time and co-ordinate every one of the thousands of jobs carried out each week on the station. One explanation of the low numbers of staff is the unmeasured involvement of other staff, especially foremen and engineers. Other major disadvantages of the system are that many plant decisions are made by planners instead of the engineers who should be involved. This led to a great deal of frustration and to manipulative practices by engineers in order to progress their own jobs. Instances were given of unpopular engineers having their work put towards the bottom of the pile. Such practices may be typical of human nature but are not conducive to the efficient operation of industrial plant.

The productivity scheme is now being phased out but it is proposed to continue timing work and planning it in the short term. One reason given is that the Health & Safety at Work Act makes it advisable for companies to have proof of maintenance procedures having been carried out. Recent interpretations of Government thinking indicate that such procedures would not be necessary.

Before leaving the planning system I will say a brief word about the work study procedures. At Ash Haven four work study engineers managed work in each of four sections; one for each station providing a work timing service, one engaged in re-cataloguing packs of work order cards for concurrent blocks of work and the fourth group to carry out job timing exercises when checks were required. Each engineer dealt with administrative aspects and made decisions about work priorities, times etc. The thirteen work study assistants were divided between these four sections. The bulk of the work was timing work order cards. On the card work is already split and many items timed. Sometimes it is only necessary to check the total and fill in the credits. At other times cards have to be referred back to the line foreman for further details. The time taken to deal with a card varies from a few minutes to perhaps a whole day. Most of the times are taken from "catalogues" of times but occasionally jobs are timed directly on the plant.

Procuring and progress chasing groups

One would expect that the functions implied by the title would be carried out by the planning branches which are supposed to ensure that resources are available. However, at Ash Haven on the staff tree (figure 8) there are seen to be two operations liaison groups, a management audit group and two project control or management groups. These five groups all have similar basic functions directed at different targets as implied by their titles. The groups are simple in structure and their duties are outlined below.

The management audit team has two main functions one of which is to develop computer based management systems on the site. The other audit function is to determine the extent to which management requirements are being met by station staff. The group maintained close links with Regional Headquarters where many computer programmes are prepared. Better management control for stores, plant history, maintenance schedules etc. were required. Audits to investigate the station's compliance with Statutory Requirements, Board's Instructions etc. were carried out at the request of station management or departmental heads. The audit team leader saw his role as being that of expert advisor of groups and obtaining compliance by persuasion rather than reporting offenders to senior management.

The two project teams were associated with the maintenance departments in each station. Their function was to facilitate and progress major outages by ensuring that programmes produced by the planners were carried out by maintenance branches. The team monitored stages in the programme and implemented it on a day to day basis at the time of the outage. It was said by the engineer in charge of one of the groups that a major function of the team was to try and generate some enthusiasm for getting jobs done and to co-ordinate and utilise the existing systems but to make the job, rather than the systems, the paramount requirement. The engineers spend much of their time overcoming difficulties such as securing services or permits and chasing manufacturers (telephoning etc.). The foremen within the group push job cards into the work system whenever necessary and the group leader brings pressure to bear on various section heads to try and ensure that programme times are held.

The other two groups were operations liaison engineers, one for each station. Their main function was to facilitate and progress work on a short term basis. As day staff they provided continuity and to this extent acted on behalf of shift engineers. They would represent the operations superintendent at meetings. They would try to overcome difficulties (e.g. permits) that were holding up plant maintenance. The declared purpose of their jobs was to improve plant availability.

They tried to arrange the most appropriate time to take a unit off load in order to facilitate the planned programme of work. They adjusted alternatives and priorities when plans were changed and short circuited the planning system on many occasions by directly seeking authority from the operations superintendent. Station management used them to provide first hand information on the progress of work.

The other stations studied had no groups performing these functions although similarly named groups existed. At Downton Station project teams had the function of planning and progressing a major outage. The difference in this case was that planning, maintenance and operations engineers were assigned to the team, normally for a single outage, and they carried out all the planning, progressing and facilitating through all its stages. There was no duplication in other departments. Normally a planning engineer provided continuity and the size of the group varied depending on the stage of work. During the actual outage several other engineers would be assigned to the group from maintenance but the operations engineer would only be deeply involved when the constant need for isolations and permits became apparent.

At Olliton Reach a day operations team provided continuity and facilitated the provision of permits etc. for maintenance but their main function was to carry out plant tests in accordance with a programme. These tests included acceptances of plant after maintenance and also routine checks on all alarm systems within the plant. At Fossil Strand the day operations team (one for each station) provided specialist engineering services for various aspects of the plant. Examples were the boiler optimization work intended to establish the optimum operating conditions after measurements, experiments and theoretical investigations. Other groups tested and modified computer control programmes for the plant.

Only Ash Haven provided groups intended to act as a duplicate focus of attention to the more vital parts of the station's well-being namely, plant availability, effective project work and general adherence to statutory and the Board's requirements.

Safety and training procedures

Training is a system maintenance function but a substantial proportion of C.E.G.B staff training is carried out at training centres, at other establishments, or training on the job. Although the training officer is involved in some aspects of training programmes, a substantial part of his work is regulating the training activities. Similarly, the safety engineer is probably more involved with regulating activities than with safety training.

The C E.G.B has headquarter's departments which select and organize training courses and run the training centres. The power station training requirements are co-ordinated into a programme by the training officer who then administers it by ensuring that appropriate staff are selected and organizational details attended to.

In addition to these duties the training officer normally participates in many 'on-site' courses, arranges for visiting lecturers and the preparation of lecture material etc.

With the increased safety legislation in recent years many safety officers have found themselves becoming administrators. Staff at Ash Haven were critical of the safety officer saying it was difficult to get him to investigate safety problems on the plant, his main concern being the records and returns required by Headquarters. In power stations certain foremen are designated for safety duties, although all foremen have a line responsibility for ensuring that safety procedures are practiced. The safety foremen give lectures and investigate plant problems.

Many criticisms were made that the C.E.G.B.'s main concern with safety was the provision of adequate systems and procedures to ensure the protection of the organization. Although this criticism is probably unfair it appeared to be the case that some safety officers were more concerned with procedures than with taking effective safety measures on the plant. It was said that any work involving safety hazards at

Olliton station was carried out within twenty-four hours whereas at another station studied examples were given of safety equipment being unserviceable for weeks. The fire and security systems installed in power stations were also criticised as being expenditure primarily aimed at "white washing" the Board. One thing that was evident from the research was the extent to which these procedures were taken seriously by the different stations. Olliton appeared to take all three procedures seriously and made attempts to provide effective services. At Fossil Strand the routine warnings were regularly tested to the extent that staff were "brain washed" and when a real fire (very minor) occurred there was no reaction from the staff because they had been conditioned by the weekly tests.

Neither the training nor the safety procedures in C.E.G B. stations appeared to be as effective as those applied in the American stations studied. Lost time accidents were rarities in the American stations and the training programme outline for the T.V.A. was far more systematic than that used by the C.E.G.B. However, about six thousand adult education or training courses are provided each year within the Region with an average duration of one week. A substantial proportion of these courses are arranged by the headquarters training groups.

Some comparisons and conclusions

The question to be answered in the section is "why the very great difference in staff numbers between the American and C.E.G.B stations"? The answer probably lies in the planning systems but it will be helpful to run through some of the other activities first.

Technical regulatory activities Test and efficiency, chemistry and reactor physics functions were all broadly similar in both countries and the higher maintenance inputs of C.E.G B. stations would require proportionately greater services. In the C.E.G.B. all these activities was still concerned with post-commissioning work, i.e. they were still inducing change in the system.

For the site services groups which were very much greater in C.E.G.B. stations, much of their work was associated with plant improvements. The only labourers in American stations were multi-purpose and most of their time was spent in the coal and ash plant. During the study of the French stations, Buckley noted that all staff carrying out work on the plant were careful to clear up afterwards. This was much less evident in C.E.G.B. stations either by station staff (working against measured times) or by contractors (working to a quoted price). Despite these considerations I was left with the opinion (particularly at Ash Haven and Fossil Strand) that these services were unproductive.

Management and administration Management structures in both sets of stations were similar, a major difference being the substantial effort required in C.E.G.B. stations to deal with industrial relations, recruitment and personnel aspects. This work (e.g. talking with shop stewards) absorbed about half the time of the management staff which might have been more profitably spent building up human contacts with the workforce. In the American stations the senior staff did superintend and were aptly named. My previous research on management teams indicated that station managers spending more time on plant maintained better industrial relations and morale. One station manager considered that direct contact with the shop floor was the function of the foreman but at this station well over two-thirds of the staff wanted a re-introduction of direct links between senior management and the rest of the staff. These links were considered to be a major line of communication and on 'two station' sites many staff suggested a splitting of the site in order to facilitate better communications.

The much larger administrative teams in C.E.G.B. stations were partly attributable to unnecessarily elaborate systems such as pay scales with hundreds of variations. The splitting of ordering and invoicing procedures between stations and headquarters also increased the workload. Typical of these systems was the C.E.G.B.'s National Contracts which negotiated lower prices often at the expense of delivery delays. In a time conscious industry such as electricity generation such delays are counter-productive and account for much of the additional workload of engineers and administrative staff. Other administrative staff were involved in the planning systems and finally, much of the administrative workload is proportional to the total staff and would, therefore, be greater in C.E.G.B. stations.

The planning activities Without doubt, the biggest difference between the two sets of stations was the planning function and its associated groups. In the overseas stations long term planning was carried out and one, or sometimes two, engineers were assigned to it. They also covered contingency planning insofar as they were responsible for preparing lists of work to be done when unplanned outages occurred. The long term planning in C.E.G.B. stations was based on critical path networks and computer programmes. The preparation of such programmes for new plant items would clearly be a matter for considerable effort followed by a high level of introspection from which an improved programme should have emerged. The station manager at Downton created temporary planning teams associated with an outage and he foresaw this group diminishing in size until, after about six outages, a permanent minimum sized unit would remain. At Olliton, the station manager created a system whereby planning teams were responsible for programming and progressing all the work on one unit. This labour intensive system was a manifestation of his philosophy of allocating responsibility to individuals. Thus it might be argued that in the C.E.G.B. power stations the long term planning function was substantially greater than the overseas counterparts because it had been created from the need to commission the plant and had, so far, failed to shrink to a steady state condition.

The short term planning system had no counterpart in the overseas stations and nor did the productivity scheme. The effects of this scheme will be discussed further in Chapter 9 since I believe it to be one of the most important single factors in the difference between C.E.G.B. and overseas stations. It is worth remembering just what short term planning seeks to accomplish. Its main purpose is to prepare a detailed work plan for the following twenty-four hours. In some of the C.E.G.B. stations defect maintenance accounted for 50%

of the work but at Ash Haven it was as high as 80%. Defect maintenance, by definition, is unplanned and, if urgent, is unplannable. i.e. There is only one answer to an urgent defect and that is to correct it. Planning systems are irrelevant to such problems and only cause delays which can easily lead to further work.

Another important point noted in the research at Ash Haven was that a number of groups disregarded the formalised planning system and in each case the individuals involved seemed to acquire adequate self-motivation to provide an efficient service.

Another manifestation of the planning system was the emergence at Ash Haven of progress chasing group whose purpose was to monitor, organize and drive (i.e. regulate) the planning groups whose function was to plan, organize and provide. The belief of several engineers associated with these progress chasing groups was that the planning systems failed because they were not rigorous enough. But it was generally agreed that the productivity had not increased as a result of the schemes and in those parts of the organization which were efficient before the introduction of the schemes, work records showed that productivity had declined. There are indications that although the systems have raised the standards of the least efficient groups it has been to attain a uniformity of mediocracy at the expense of any efficient group which existed before the scheme was introduced.

The other major change associated with the introduction of the productivity schemes has been the much greater involvement of R.H.Q. staff. Much of this involvement stemmed from the introduction of the schemes when teams from headquarters established the groups in the power stations and introduced the schemes. They then monitored them closely and devised other management techniques for monitoring station performance. Some of these required considerable effort on the part of the stations such as the annual production of station plans. Most of these plans are elaborate and it would not be sufficient for a station to say that it intended to continue in a steady state for the following year. The other change in recent years has been the close involvement of the group managers in the affairs of the station over which they have executive control. In the early days of group managers there were a great many small stations within the Region and the idea of having one headquarters spokesman to cover a number of these seemed reasonable. Now, with most small stations gone, more direct access for station managers to headquarters would seem to be desirable. To sum up this latter part, the difference between C.E.G.B. and American practice in terms of headquarters functions is that the overseas headquarters studied were mostly concerned to provide services to the stations whereas C.E.G.B. stations have most of the service built-in and the matching services at headquarters are therefore more pre-occupied with monitoring the stations. It is very probable that the best way to "spike" such monitoring would be to make greater use of the headquarters services as is done in the American stations. It is probably a truism to say that people involved and associated with an activity are far less likely to be critical of it.

CHAPTER 8

THE IMPROVEMENT ACTIVITIES

Introduction

Perhaps I should remind the reader that my definition of improvement tasks comprises all those intended to bring about improvements or changes to the plant. In the overseas power stations no such groups existed but all the C.E G.B. stations studied had these groups. As far as I am aware,none of the C.E.G.B power stations in this study carried out any improvements to the station as it was originally conceived. To this extent, "improvement" is something of a misnomer and the main purpose of the work carried out by the development teams was to bring the plant to the state where it could achieve its designed performance. The nearest equivalent to development work staff in the American power stations was the provision of several additional staff during the post-commissioning period and these were evident at Sequoyah station. Most were on secondments of two to three years and at Bull Run station several posts had been disbanded about three years after the final commissioning of the station.

Recently, a change has been made in the C.E G.B. structure insofar as all the development teams in power stations are now classed as headquarters outstation units. On this basis there are now no development teams belonging to the stations. In practice, very little has changed except the direction of the work is now a regional headquarters function. Already at Fossil Strand a station staff group has been created to carry out projects under the direction of the station. The reason behind the need for development teams in C.E.G B. power stations partly derive from the enormous building programme undertaken in a period of a very few years and part of the outcome of which were the four stations in this study. The Power Corporations studied in America had a much steadier rate of construction.

Improvements in American stations

One very important factor influencing the need for development work in American stations was the procedure for setting them to work. In the stations belonging to both power organizations that I visited the construction division were responsible for the initial commissioning and operating of the new plant. I don't believe this was a safeguard applied by the generation division because most of the facilities for carrying out modifications and troubleshooting existed within the construction division. It was therefore a question of the construction division seeking the facility of operating the plant as and when required and finally handing it over in good working condition. One would also suppose that inherently faulty plant would be much more rapidly designed out of future stations by such a system. Any subsequent major work in the American stations was also carried out by the construction division and during my visit to the Marshall plant the major outage was to include an additional precipitator to meet the new Federal requirements. In the Duke Power Company major maintenance was also carried out by construction division teams but with the T.V A. (almost twice as large an organization) the maintenance teams were a headquarters facility of the generation division.

All the major maintenance problems and all specialised technical problems were dealt with by the headquarters groups who were much more closely integrated with the power station organization than is the case with the C.E G.B. Stricter Federal requirements affecting both smoke emission and cooling water temperatures are giving rise to additional plant at many United States power stations. Undoubtedly the Three Mile Island incident will give rise to further modifications to some of the nuclear plant. Apart from such changes it appears to be the philosophy of the American power corporations to get new power stations into steady state operation as quickly as possible and then leave them there. With the enormous potential for earning revenue associated with the power station this would make good economic sense and the recruitment of essentially steady state staff would underline this requirement.

Improvement teams in C.E.G.B. stations

The substantial numbers of problems encountered with the 500 MW units took the organization by surprise and led fairly rapidly to the creation of development teams in these power stations. At Downton station this development team quickly became the commissioning team and performed many of the functions presumably carried out in the American stations by the construction division. At Downton during the initial commissioning phase the rest of the station was under the direction of this team and this was the historical reason why the planning and test and efficiency groups are still a part of that department.

The commissioning of a station generally involves the operations and maintenance staff in familiarization studies, the preparation of manuals describing how to operate and maintain the plant and the carrying out of tests and procedures on items of plant as completed before signing acceptance certificates. This was the procedure carried out at Olliton Reach, part of which was described in Chapter 5. However, after the initial operation of the plant the number of faults and difficulties arising quickly reached proportions which precluded efficient operation. Over two thousand faults or shortcomings were identified on each of the units and it was realized that the only satisfactory solution would be to create a group to concentrate on those faults without the distraction of everyday maintenance. Having cleared the majority of the faults the development team was reduced in size and carried out duties similar to those which will be described for the other stations.

At Downton station many of the major problems have already been outlined in Chapter 2. The development department which had subsequently become the commissioning department fairly quickly reverted to the development role following the commissioning of the last unit and a continuing programme of substantial modifications is currently in progress.

At Fossil Strand the development team was built from an existing project team with the advent of an increasing workload associated with the new station. It is described in the next sub-section.

Ash Haven was unusual in having two groups coming under the general classification of improvement. These were a development department carrying out a series of plant improvements (minor and major) and a team created to rebuild the 500 MW unit which disintegrated. At the end of that project they were regrettably faced with the need to repeat the process for another 500 MW unit which had also disintegrated. They were especially interesting as a group because the function they were carrying out was the nearest approach within the C.E.G.B. to the American practice of power station construction. The working of these units will also be discussed in a following sub-section.

Fossil Strand development team

The team was nominally a department but so tight knit that the term 'team' is more appropriate. The departmental head reported to the deputy station superintendent but was otherwise not closely integrated with the station structure. The department stood aside from day to day station matters and could have been replaced by an outside company performing the required plant improvements without any visible changes in behaviour patterns from the team members. The organizational structure of the team is shown in figure 13.

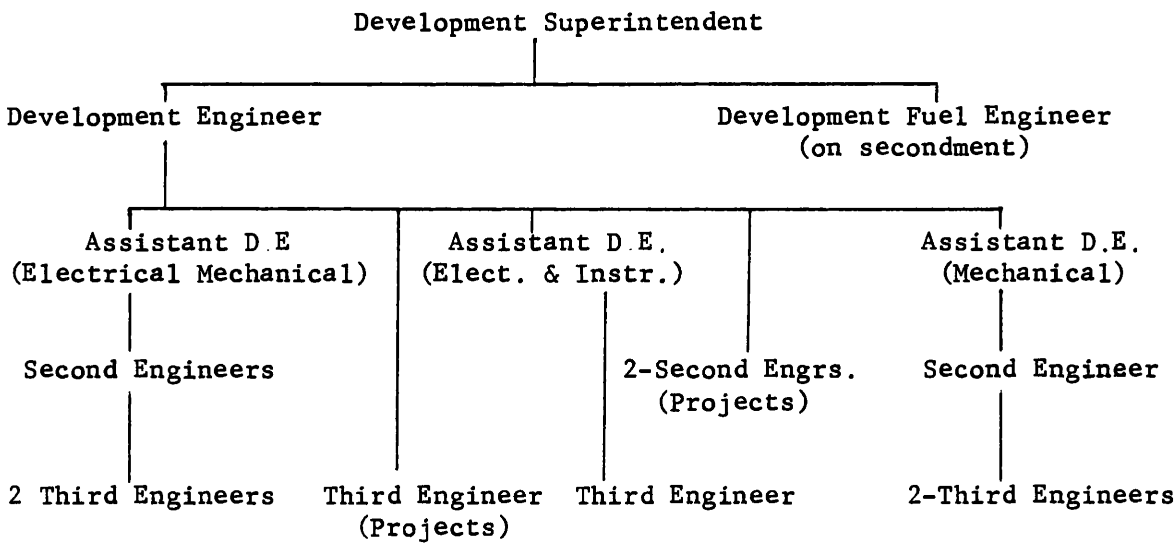


FIGURE 13 FOSSIL STRAND DEVELOPMENT DEPARTMENT

The formal structure changed from time to time to suit the particular projects in hand. Two additional groups effectively belonged to the department and these were a small clerical team (3 staff) who were assigned from the administration department and a group of fourteen contract draughtsmen together with a group leader all of whom were probably as permanent as the rest of the development department's staff.

The informal structure generally followed the lines of the formal one but departmental policy was determined almost entirely by the development superintendent and the development engineer who acted as his deputy. They each had differing roles in the department, the development superintendent having charismatic leadership and involving himself in the activities of all members of the department much along the lines of the reactor physicist at the same station. His deputy was the "hard man" and, although not disliked, his role was to apply the pressure, ensure programmed dates were adhered to and that satisfactory progress was being made on the various projects. They each played similar roles in relation to the external environment with the development superintendent discussing and accepting new projects and generally providing forward drive in much the same way as an entrepreneurial boss would drive his company. The role of the development engineer was very often to put pressure on equipment suppliers and outside contractors. Much shorter delivery times than were normally offered were frequently required to match the promised completion dates made by the development superintendent. The two made a very formidable driving team and drew the three section heads into policy discussion from time to time in relation to the allocation of projects within the department.

In relation to the projects handled the department behaved as a series of services giving a matrix type of organization. Very large projects would be led by the departmental management but substantial parts would be hived off as sub-projects allocated to engineers. Other engineers, especially those in the electrical section, became partly involved in many projects in the department by providing the electrical guidance. The medium size projects were generally steered by the section heads but frequently would be allocated by them to one of the engineers within their section. This allocation or handing-over was real as two of the engineers with whom I had discussions assured me that they worked outside the sections and were answerable to the departmental management. However, the section heads confirmed that they nominally belonged to the sections and work was informally monitored during the many inter-person discussions which took place within the department.

Method of working Virtually all the work in the department is of a project nature and the practice is to allow an engineer to complete a project from inception to completion. Each engineer handled three or four projects at the same time but usually in various stages. Normally only one would be of a substantial nature and smaller projects might consist of supplying and installing a unit of proprietary equipment followed by testing and handing over the completed job. Often gaps occured within projects e.g. the waiting periods for delivery. The stages of all projects were similar and the tempo of work generally increased from the start to the completion. In nearly all cases the actual installation work was carried out by contractors and station staff were only rarely involved.

A series of systems and procedures was established within the department and these greatly facilitated the work and also the monitoring of progress and spending against the budget. Most projects required contract specifications and many details of these were standardized by the preparation of booklets e.g. defining the standards for welding. This greatly simplified specification writing and also assisted many contractors since they were not under the need to read all specifications in great detail in case an engineer had some idiosyncratic ideas for which he would have to allow. Figure 14 shows the work flow diagram used by the department and on it I have typed the level of involvement typically required by the project engineer.

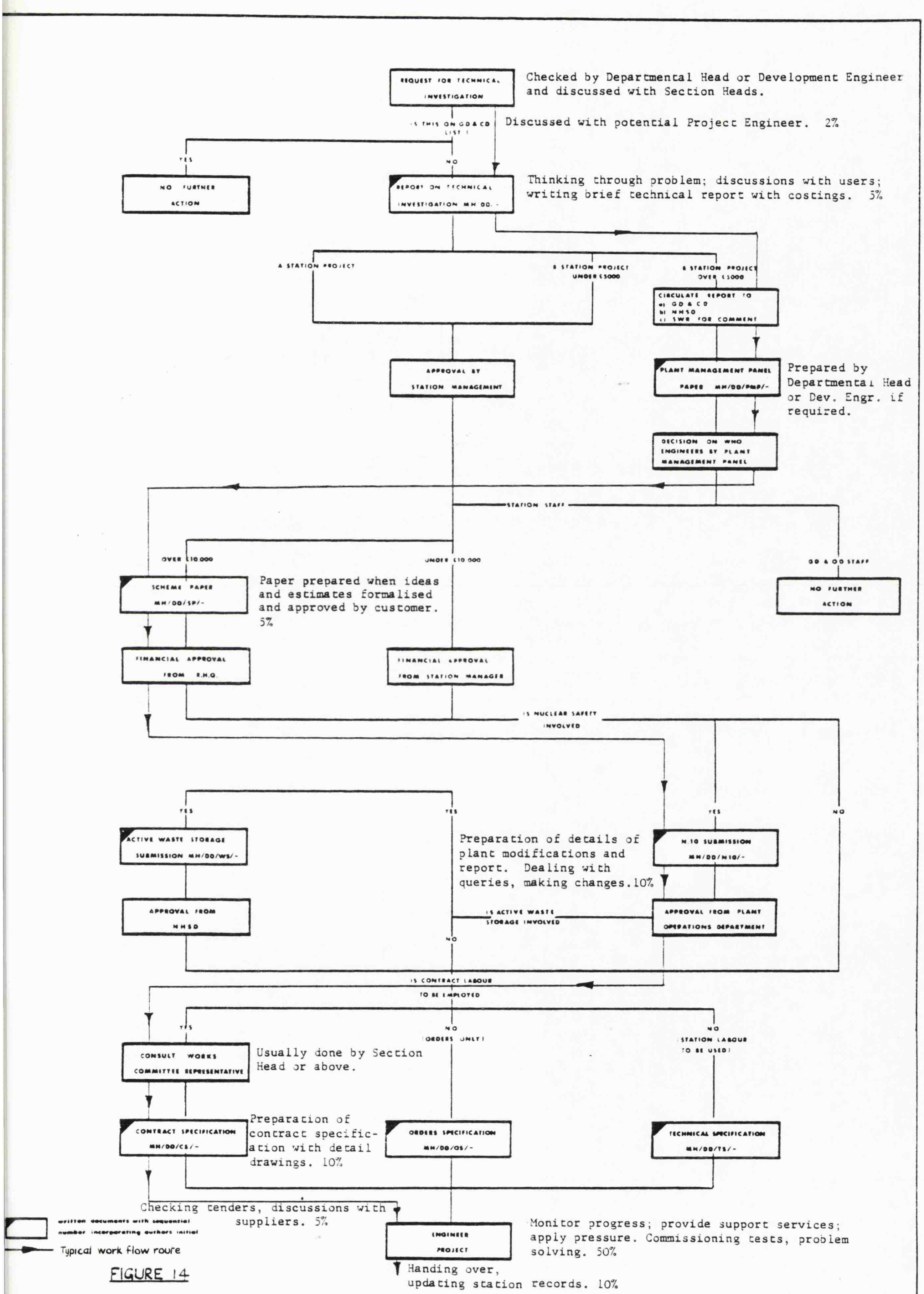


FIGURE 14

OSSIL STRAND POWER STATION DEVELOPMENT DEPARTMENT - SEQUENCE OF EVENTS FOR PROJECT ENGINEERING SHOWING DOCUMENTATION REQUIRED

Percentages are proportions of project engineers time on various stages of typical job.

From an analysis of the work of the engineers within this department average percentages of time spent on various functions were calculated for all the staff with the exception of the departmental superintendent and his deputy. The figures were:-

Managerial activities	3%
Supervisory duties	17%
Theoretical engineering	10%
Technical engineering	33%
Technician duties	5%
Administrative tasks	40%
Total	108%

Despite the efficient administrative procedures within the department 40% of the time of the average engineer was still spent on this function. A substantial proportion of this went in seeking, organizing and progressing orders and supplies and in facilitating services for the contractors men on site. Examples would be,arranging permits or an electrical supply close to the work source. A third of the average engineer's time was spent in technical engineering matters which I have defined as problem solving based on plant knowledge and experience rather than engineering theory. The technician type duties were mostly associated with the commissioning phase and the supervisory duties almost exclusively related to supervising the work of contractors. The managerial activity is a bit misleading since, multiplied by three, it represents the value typically recorded by section heads.

All engineers liked the working system which gave adequate levels of responsibility to individuals. They found the general pressure of work was high and became excessively so when major contracts were being commissioned. Most of the engineers felt that the work made a reasonable use of their skills and ability although one or two expressed a preference for mostly theoretical work. A friendly working atmosphere existed within the department and many social contacts were continued outside work. Many of the departmental members had belonged to other parts of the station organization and all felt that the department offered greater work satisfaction than any other departments on the station.

It was interesting to note that the new engineering services department at R H.Q. (which has now taken over the development departments) was created on a system using different groups of "expert" staff to handle each stage of a typical project. Thus, problem solving engineers would decide how the problem was to be tackled and then hand over the preferred solution to another group of staff who would deal with the contractual procedures and prepare detailed drawings. They in turn would hand over the contractual surveillance and equipment testing to a third group of staff. It is very probable that such specialist groups of staff would become more "expert" in their own fields, but the loss of continuity, the loss of commitment and the loss of flexibility would probably greatly outweigh the advantages of expertise. Another very important criticism is that responsibility for solving a problem should only be given to one individual (or group) and not spread over three successive groups.

Ash Haven Improvement Groups

The development department was similar in many respects to that at Fossil Strand with groups of five engineers in each of the three sections covering mechanical, electrical and instrument work. The engineers tackled the problems in their own field and followed them through all the stages in much the same way as the engineers at Fossil Strand. Three other groups also existed one, called the technical services section, tackled composite problems and after the initial investigation tended to break them down into sub-projects and then allocate them to other sections. At Fossil Strand this role was generally carried out by the departmental management including the section heads.

Another group called the construction section were concerned with seeing one major project through, mainly boiler modifications. Their tasks was to monitor the contractors work on the units and their role was that of engineering clerk of the works. Some of its members were on shift. The contract draughtsmen at this station were managed by two C.E G B. draughtsmen who allocated the work and effectively provided the drawing office service for the rest of the department. They said that being able to get away from the routine of drawing board work allowed them to provide additional services to the engineer including measuring up, preparing drawings of plant units or identifying parts of circuits on diagrams.

The feeling of being separate from the rest of the station also existed at this location but was not so sharply defined as at Fossil Strand. The reason for this was the system of job rotation for engineers which was especially criticised by those engineers in the development department affected. They said it was very frustrating to move-in part way through a project and even more frustrating to move-out before you had seen it through. They felt any such moves should have been geared to the start and finish times of projects.

The commissioning team This team had one or two interesting features which made it worthy of a little further study. Its position in the organization was to some extent uncertain since the whole of the work was being paid for by the Generation, Design and Construction Division (G D.C D). This body had delegated responsibility for all the site work to the commissioning engineer who was answerable to them. However, the station management were the clients and the commissioning engineer had a responsibility to them to ensure that the unit was re-commissioned as rapidly as possible but in a first-class condition. Therefore, one role of the commissioning engineer (representative of the client) was to ensure that the work carried out by the contractors agent (himself in another role) was of a high standard. This conflict, together with the conflicting requirements for speed and quality, caused him to think through and define the organizational standards he would adopt. The work had much in common with the commissioning of a new power station except that part of the labour force was under his direct control. The nearest equivalent to his position was that of station manager commissioning a small station with the Ash Haven station manager taking the role of group manager.

He said that fortunately the G D C D engineers did not further complicate the situation and allowed him considerable discretion. A major single part of the work was the installation of a new 500 MW turbo-alternator and he believed he was setting much higher standards than were normally acceptable by insisting that every component supplied was strictly in accordance with the specification and detailed drawings. From examples given and practices described it would appear as if this was something unusual for the equipment suppliers who often argued that the engineering standards were in accordance with normal custom and practice when they differed from the specification. Examples were given of specific instances and these are interesting because it might be an indicator of the causes of much of the technical follow-up work required in C E G B. power stations after commissioning.

Returning to a description of how the group worked the organizational chart is shown in figure 15 and as can be seen, the teams divide into sections covering plant areas. The two turbine groups of engineers were mainly concerned with monitoring work on the plant, mostly by substantial teams of contractors men. The other two groups were more directly involved in the work since much of it was carried out by the industrial staff. It will be seen from the chart that all the industrial staff came under the boiler plant section head and this was in fact the case as he had line responsibility for industrial relations and all administrative matters relating to the industrial staff such as overtime, leave etc. Technical direction of the work of the electrical and instrument groups was provided by the electrical and control section head working through the foreman. All the engineers were very conscious of belonging to a team and felt separate from the rest of the station. A dispensation had been made in the case of the junior engineers allowing them to continue with the team until completion of commissioning. The industrial staff also formed a socially close group with the foreman belonging to it. Their work was not controlled by the planning and productivity scheme in the same way as the rest of the station staff and they were encouraged to carry out the rebuilding work to very high standards. The commissioning engineer said that when recruiting the industrial staff he had to

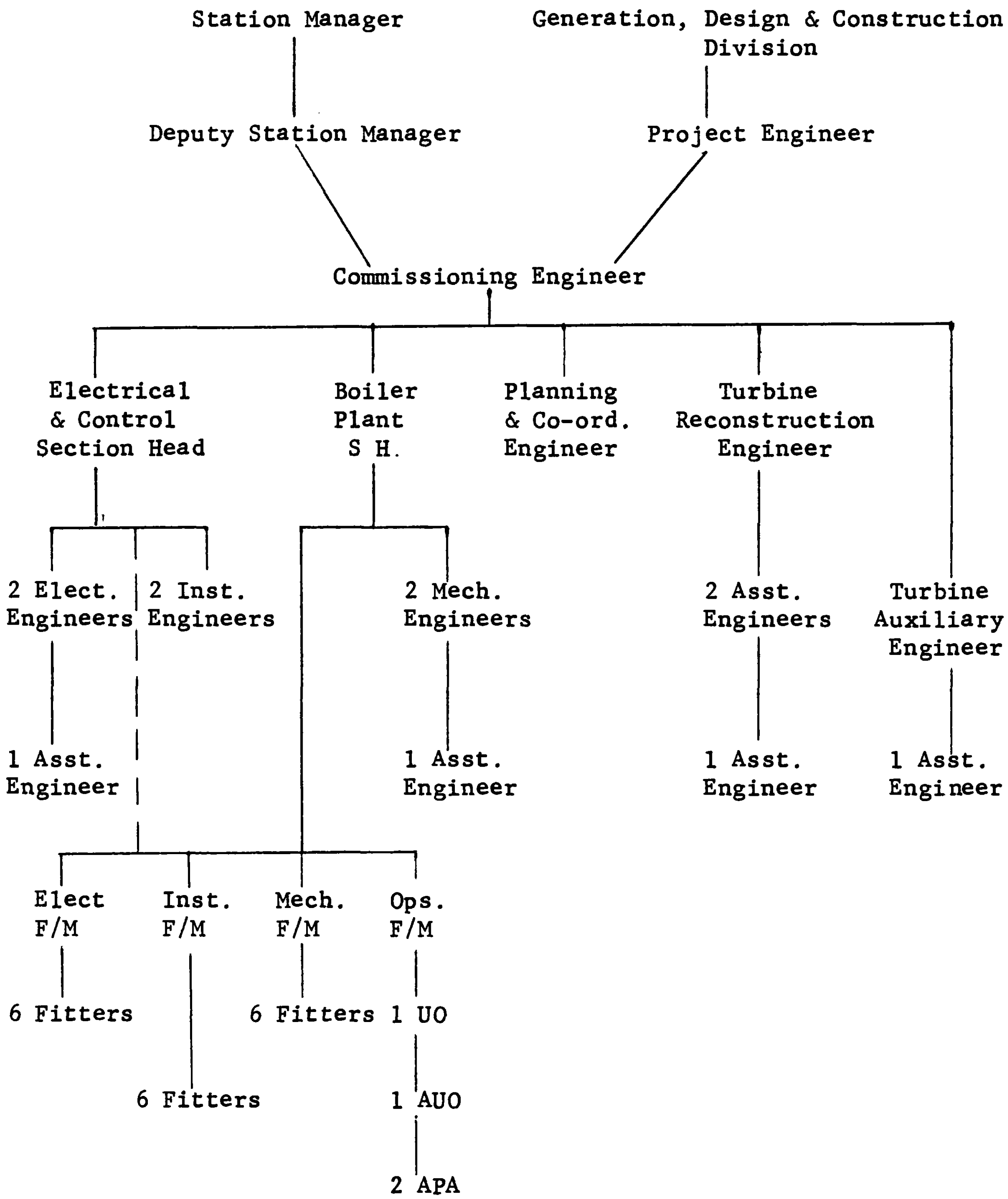


FIGURE 15 ASH HAVEN COMMISSIONING TEAM

accept "difficult" members from the other station departments who had taken the opportunity of unloading those members of staff with bad sickness records etc. A very interesting feature of this group was that their performance was considered to be extremely good and this included time-keeping, sickness levels etc. The boiler plant section head who had responsibility for their welfare made a practice of holding regular meetings with all the industrial staff at which problems were discussed. Part of his policy was to present a realistic picture of difficulties and to avoid making promises which he couldn't keep. The fitters interviewed all confirmed that the satisfaction of working within the team was the sense of working towards a common goal and the ability to turn out top quality work taking whatever time was necessary to complete it. The greatest frustration of the team was the opportunist way in which many items they had rebuilt were borrowed for use on the operating plant and defective items returned in their place. Thus it would seem as if the satisfaction of achieving an overall goal was greater than the satisfaction of completing first-class units of work.

<u>Some improvement task deductions</u> The common feature of the development team (and the commissioning team) was the ability it conferred on the members to see a job of work through from start to finish. This satisfaction was particularly marked for the commissioning team where their satisfaction was the rebuilding of a complete 500 MW unit within a reasonable timescale (about two years). The sense of common purpose of the commissioning team was only marred by the division between N.J.B. and N.J.I.C. staff, a division of the "officers and men" type. This was strange since the common task and target was identical for both groups. However, this division seems to have existed in all the C.E.G.B. stations studied and I was only told of one location where regular social occasions occurred involving both groups of staff.

The working of the commissioning teams was probably the nearest C.E.G.B. equivalent to the American commissioning procedures but since I have no first-hand information on those this suggestion is only conjecture. I see the similarity being in the sense of commitment to a satisfactory outcome of the work by people who have links with the station. Although the project engineers associated with commissioning new power stations in the C E G B ought to have such a commitment, in practice, the biggest pressure on them in recent years has been to complete the work and move out. This work pattern raises the question of whether so many of the post-commissioning problems are due to inherently faulty manufacture or to the ability of the manufacturers to "get away with it". Certainly at Ash Haven delays in the new turbine installation were caused by rigid insistence on the quality standards defined in the specification. Similarly, at Fossil Strand the development engineer recounted several cases of contractors complaining that they were losing money on a particular project. This was generally because they had put in a very low tender expecting to get away with substantial "extras" when they were on-site doing the work. He said the policy of that department was to write tight specifications so as to minimise extras and to hold the contractors firmly to the terms of the contract. He said it was also policy for the department to check with any contractor in situations where very low tenders were submitted so as to be certain that he (the contractor) was aware of the full extent of the work required. The implications of some of the working patterns of these departments in terms of staff morale and overall efficiency will be discussed in the next chapter which will take an over-view of the whole of the power station organization.

CHAPTER 9

A REVIEW OF THE ORGANIZATIONS

Introduction

In this final chapter of part 2 of the thesis I shall consider the main organizational features that have emerged in the previous four chapters and try to draw some general conclusions. I shall pull together the series of comparative studies linking the C.E.G.B. and overseas stations and add some statistical data from the detailed investigations carried out.

The differences between stations will be related to research by others and evidence will be produced in support of some of the conclusions. I shall attempt to answer the questions "what are the differences and why are they so?" in relation to the stations. Later in the thesis I shall try to identify the underlying causes after a historical review of the industry.

The first subject for further study is the system I used for analysing the jobs in power stations. It will be used to compare differing existing systems. Some implications for the organization structure will be compared with the data from previous chapters.

The next topic studied will be the variation in station staff numbers. The reasons will be examined in this chapter in the context of the power station structures and in Part 4 the wider context of the industry.

Other effects on the staff arising from management policies will be sought in the research data and particularly the Ash Haven attitude survey. These effects sometimes appear to be the opposite of those intended by management.

I shall start with work classification and relate my system of core generating, system maintenance, regulating and improvement activities to the systems used by the industry. These are classifications according to staff grades; working cycles and organizational hierarchy. The comparative study will measure the congruence which might exist between them and analyse the divergencies.

Staff Classification according to negotiating bodies

The majority of staff in C.E G.B. power stations either belong to the industrial grades whose conditions are negotiated by the National Joint Industrial Council (N.J I.C.) or to the engineering grades whose conditions are negotiated by the National Joint Board (N.J B.). The bulk of the remaining staff are the clerical grades and conditions for them are negotiated by the National Joint Council (N.J.C.). The two major groups probably owe their origins to the "officers and men" division in the armed forces with the "men" sub-divided into N C O.'s (foremen and chargehands) and others. Many of the traditions and staff patterns of the C E.G B. were based on navy practice (the technology had similarities) and many ex navy men joined the C E G B. These links are mentioned much less often nowadays than was the case ten years ago. Managerial and technical work is carried out by N J B staff nearly all of whom are classed as training engineers even though less than 20% are chartered engineers. The senior management levels within the C.E G B. are almost exclusively recruited from the N J B. staff and belong to the National Joint Management (N.J M.) negotiating body. Until recently only the station manager on a power station was graded N.J M. but the grade is now being extended to departmental heads. As a result of the promotion system nearly all the senior posts within the C E G.B. are filled by ex power station managers.

The clerical (N.J C.) group covers staff in all levels of the administration hierarchy and includes those carrying out routine tasks, those exercising professional skills together with many of the administration managers. (A few senior headquarters administrators are N.J.M.). This is in contrast to the situation for the technical staff with the division between the "doers" and the "thinkers" broadly coinciding with the N.J B. and N.J.I.C. division.

The N.J.I.C. staff can be broadly sub-divided into three levels:-

foremen; skilled; semi-skilled/unskilled.

Each of these levels encompasses a wide range of trades and skills with the main difference between foremen and skilled being the additional experience required and the very different duties carried out. The semi-skilled to unskilled is the broadest band and ranges from those near to skilled in duties to those who are totally unskilled. It also includes a number of staff who will progress to skilled posts together with those whose abilities will limit them to unskilled work on a permanent basis. This broad spread of abilities is in marked contrast to the much more limited range for engineers. Most power station engineers either have basic mechanical or electrical engineering training and some specialise in electronics. A very limited number have chemistry or physics qualifications and one or two now have such specialisms as computer technology, systems analysis etc. All the engineers possess some qualifications and in certain cases the Board will impose tests the passing of which enable an engineer to be classed as Trained. Provided this barrier is passed there is no other bar to progress for N.J.B. staff other than their ability and experience. For the N.J.I.C. staff the lack of an apprenticeship can be a significant progress barrier in certain trades. Another generalisation is that the managerial duties for the N.J.B. staff are normally associated with the more senior levels. Qualifications are less necessary for administration staff but the more senior posts for administration in a power station are normally associated with some qualifications.

This is a brief review of how power station staff within the C.E.G.B. are classified according to negotiating bodies together with the main sub-divisions. It should be pointed out that such classifications are not necessarily used in other countries. For example, in France, all power station staff have a grade on one scale. A labourer might be a 2 or a 3; clerks and fitters would rate about 6 or 7; the station manager would normally be about 14. Within the American T.V.A. organization there were grades for industrial staff, for engineers and managers. However, all the gradings merged to provide a continuous path associated with the necessary training and experience. An operations superintendent would almost certainly have started as an unskilled plant attendant and would be considered perfectly eligible for station manager posts.

Power station working cycles

In most C E.G.B. power stations three main working patterns are used:-

Shift; Stagger day (seven day working); Five day (Monday to Friday)

(Chapter 10 takes up the question of shift work in depth)

Engineers on shift work a five team rota which allows for time off. The N.J.I.C. usually adopt a four team rota which requires time to be taken off when on the work cycle.

Various shift cycles are adopted but the most favoured ones are variations on the 'continental' pattern which avoids continuous periods on any one shift (especially nights). The usual span time for shifts was five weeks and this allowed for time off. The other common cycle (mostly worked by N.J.I C.) is the four week cycle and this requires a certain proportion of the staff scheduled for work to be on time off.

The seven day working pattern basically requires two groups for cover and gives rise to periods of overlap when both are in. This peaking is minimised by operating with four groups and spreading the overlaps. Levels of weekend working vary from two in four to five in six and the additional pay for weekends is probably as important a determining factor as the actual plant needs. Seven day working applies almost exclusively to N J.I C. staff. One or two chemists and planning N.J.B staff are sometimes involved in weekend work.

The five day working pattern applies to all administration staff, all managerial and most engineers with the exception of shift staff. In overseas power stations similar systems are used but to a lesser extent. Seven day working invariably involved one weekend in two.

Management Structures

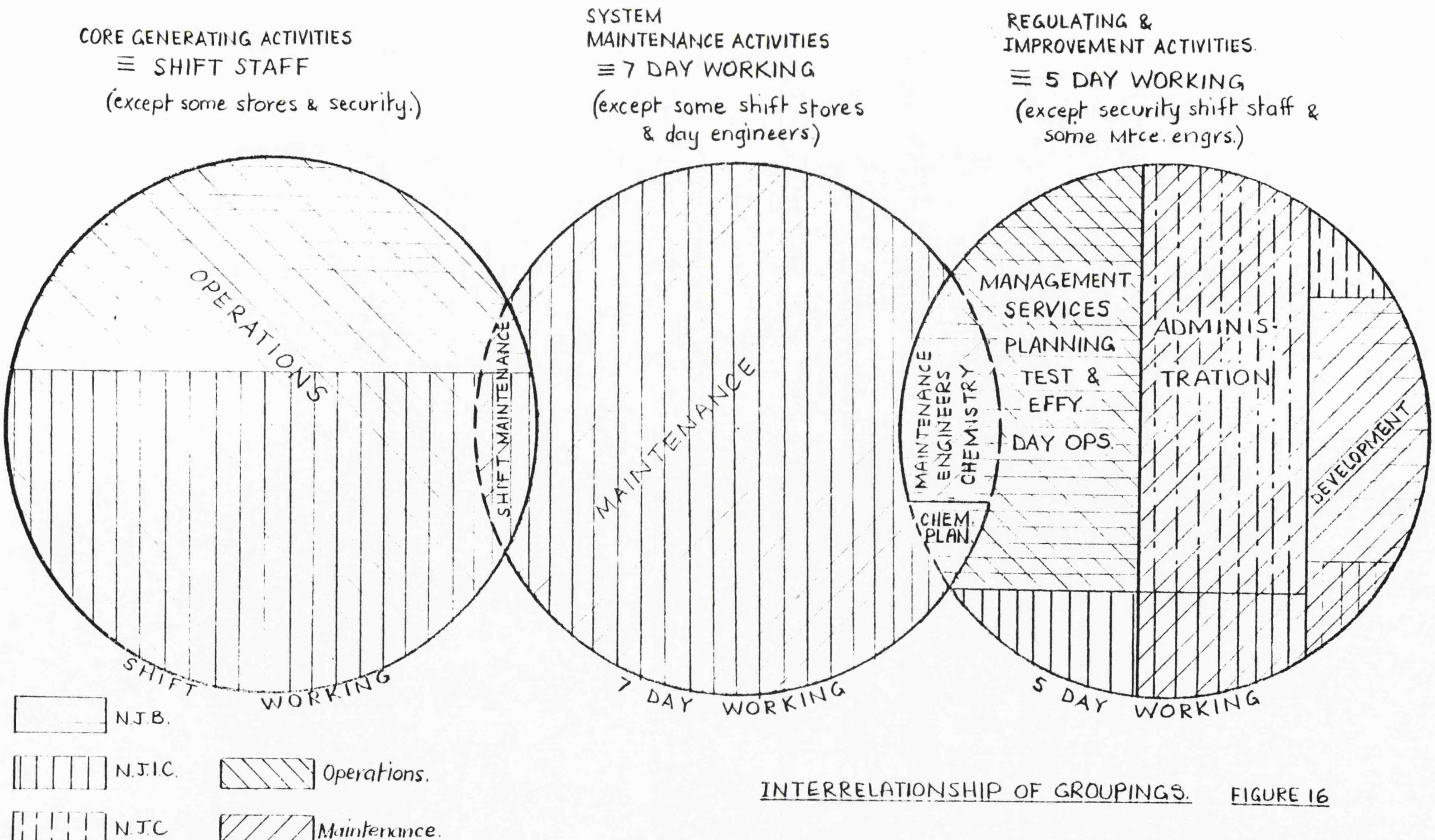
The majority of staff in a typical modern C.E.G.B. power station belong to one of five departments namely:-
Operations; Maintenance; Administration· Development· Management Services.

The new C.E.G.B. structure groups operations and maintenance into production but hives off the maintenance engineers who become engineering services. In U.S. power stations operations and maintenance comprise over 80% of the total staff so such an amalgamation would be of little value.

A less clearly defined division would be into line and service staff. This would place all the above departments except operations into the service staff and give a substantial numerical bias towards the services. In some of the American power stations studied such a division would create about equal sized groups of line and service staff.

Relationship between staff classification, working cycle and management structure

The various categories may relate empirically to my analytical divisions and are discussed. These relationships are set out in figure 16 and show a broad congruence existing between the various classifications for C.E.G.B. power stations. The only one to cut across the boundaries was the classification according to the staff negotiating bodies. The three circles represent shift, seven day and five day working staff. Close matching is achieved between shift staff and the core activities. The maintenance activities only overlap into five day working because maintenance engineers normally follow the five day pattern. Nearly all the regulating staff and improvement staff work a five day pattern. It is evident that the departmental divisions mostly follow this grouping. The shift maintenance staff are closely associated with operations because they work shifts and are classified as core activities. The system shows up other anomalies such as all maintenance engineers working a five day week when the industrial staff work a seven day week. One would expect the N.J.B. and N.J.I.C. to figure in the seven

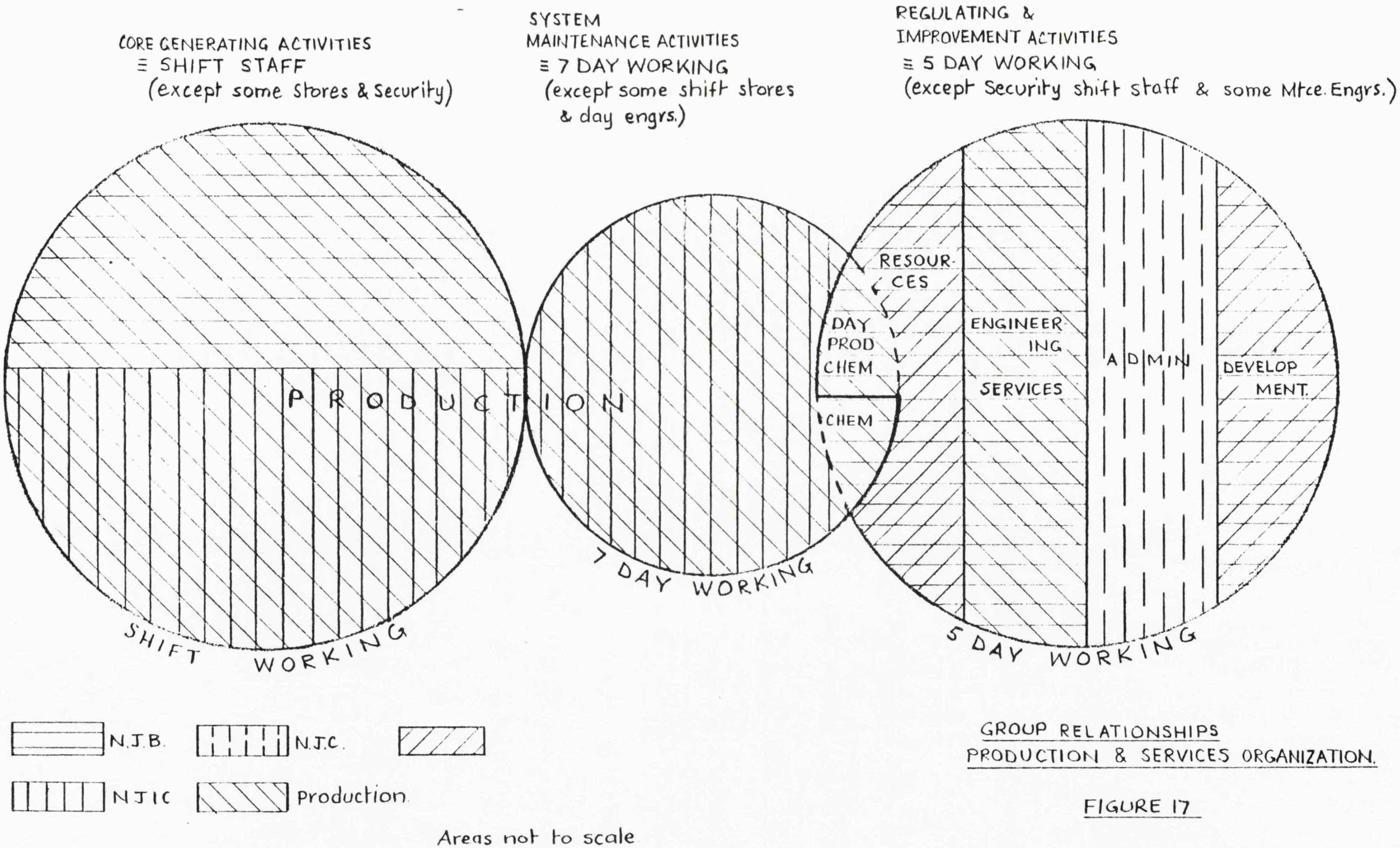


INTERRELATIONSHIP OF GROUPINGS. FIGURE 16

Areas not to scale.

day pattern if their duties were maintainance activities rather than regulating functions. In the event, day maintenance engineers generally mix these functions and the diagram suggest that some N.J.B. staff should be on seven day working. On nuclear stations the health physics group have a core role with some of their members on shift similar to the shift maintenance staff. The remainder of health physics are divided into seven day working for industrial staff and five day working for engineers. Thus they spread across the whole of the diagram and, indeed, their role within the organization is that of overseer and could be regarded as a form of insurance. Most of their duties are simple, examples being: taking geiger counter readings, issuing and washing clothes, checking exposure records. The vital nature of the work they do justifies a separate and responsible body to carry out their duties. The influence of such a body is bound to spread across the whole of the organization. The reactor physicists perform a similar role to that of the chemists but, of course, in relation to another area of the plant. The "advice" of both groups in relation to plant operation is equivalent to technical instructions.

The new system to be adopted for C.E.G.B. power stations comprises production, engineering services and resource departments and would give rise to substantial changes in the structure if put into practice as planned. The kind of structure emerging is illustrated in figure 17 and shows the core, maintenance, regulating and improvement activities as before. The overlaps between seven day and five day working are virtually unchanged with the chemists shown working both five and seven day patterns. The big difference is the lack of overlap between the shift working and the seven day working and this is due to the amalgamation of the maintenance function into the operations to give production. The diagram shows most of the production staff on shift and some on seven day working. The lack of overlap assumes that those maintenance staff on shift are all engaged in core activities and all those doing system maintenance duties are on seven day working. On this artificial basis there would be congruence between the timescale of work and the working patterns. There is clearly no congruence between the organizational departments and the type of work since production spreads across all three working patterns. Some of the



GROUP RELATIONSHIPS
PRODUCTION & SERVICES ORGANIZATION.

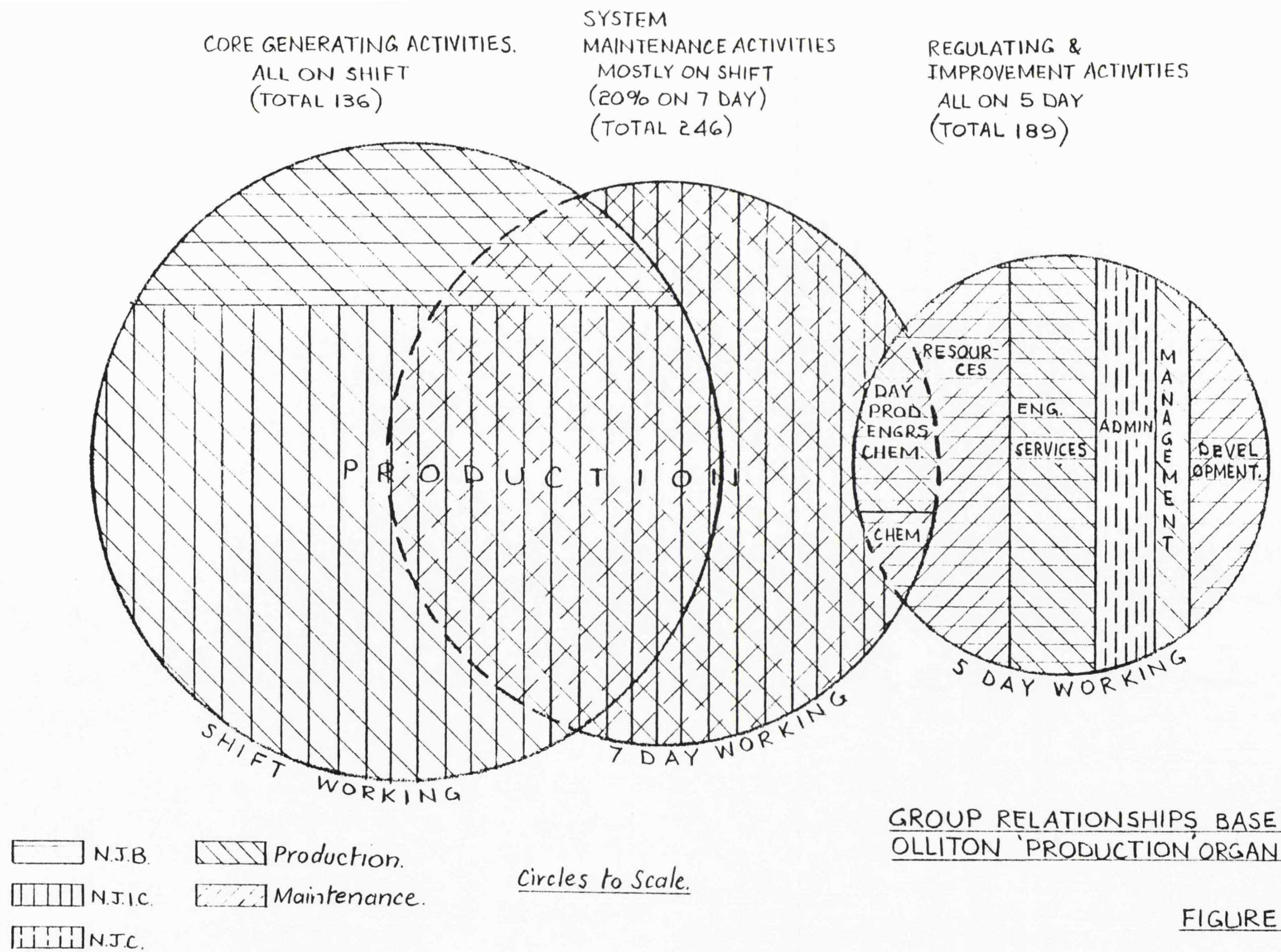
FIGURE 17

implications of this system will now be considered using two of the power stations studied as examples.

Organizational analysis using the classification

The production system displayed in figure 17 nicely assumed that all maintenance work done on shift was core activity and all the system maintenance activity was on seven day working. However, this was not the case at Olliton Reach even under the operations and maintenance regime. The type of structure proposed is displayed diagramatically in figure 18 and shows a substantial overlap between the shift and seven day working with much of the system maintenance function carried out on shift. The proposal was that 80% of maintenance work would be carried out on shift although no additional engineers to supervise it would be provided. It was apparently part of general C.E.G.B. policy under the proposed production regime to carry out most maintenance work on shift. Therefore, figure 18 will be representative of any power station using this system. Although Olliton Reach has nominally changed to the production system its actual working organization is based on the operations and maintenance departments and similar to the one shown in figure 16, but with a much larger overlapping shift maintenance area.

I obtained some information about the background to the adoption of this system at Olliton. It was apparently in use at an adjacent oil refinery and this was the "trigger" for its adoption at Olliton. On investigating further I ascertained that the engineering services manager (known personally to me) continued to use direct links for the direction of the maintenance fitters work even though the latter were nominally under the direction of the production department. These effectively recreated the maintenance department and reduced the line authority of the production management. The links also short-circuited the resource allocation system (planning) which determined the fitter requirements to meet the engineering services needs. Apparently at the refinery the informal system worked well enough but such deviations from a formal system are likely to give rise to counter-



GROUP RELATIONSHIPS BASED ON OLLITON 'PRODUCTION' ORGANIZATION.

FIGURE 18.

productive activities by individuals working according to the official system.

Before going on to discuss the anomalies it might be worth looking at Marshall plant's simple organization using the same type of diagram (figure 19). It has three circles with no overlaps, but this is with chemistry in system maintenance category. The coal gang shown as carrying out shift work is only partially representative since they work a two-shift system seven days a week. They have been classed as core activity staff to accord with the classification given to the C.E.G.B coal gangs. The stores, maintenance and the chemists all work seven days and no overlap has been shown for the engineers in charge because the same individual provides engineering expertise and management. For this diagram I have considered the departmental heads as being members of management and therefore regulating functions. The other regulating groups work five days with no overlap unless required to stand-in for shift staff. In addition to the lack of overlaps the internal divisions into separate groups are mostly artificial since the coal gang is part of operations and the stores and chemists are part of maintenance. However, maintenance is divided between two departments each of which carries some five day regulating functions which are discrete groups as shown in the diagram.

For Marshall plant therefore we have all core activities carried out on shift and all belonging to one department· all maintenance work carried out on seven day working and shared between two departments; all regulating functions are five day working and are spread throughout the organization. The gatekeepers and cleaners are contract staff (thirteen in total) and have not been included in the diagram. It is also worth noting in this diagram that there are no horizontal divisions representing different grades of staff in the same function. It should be noted that I have not included different levels in the same grade e.g. foremen. The engineers constitute a different grade and they all comprise separate groups on five day working. Also the administrative staff would be paid as clerical workers but the small numbers would hardly merit a division.

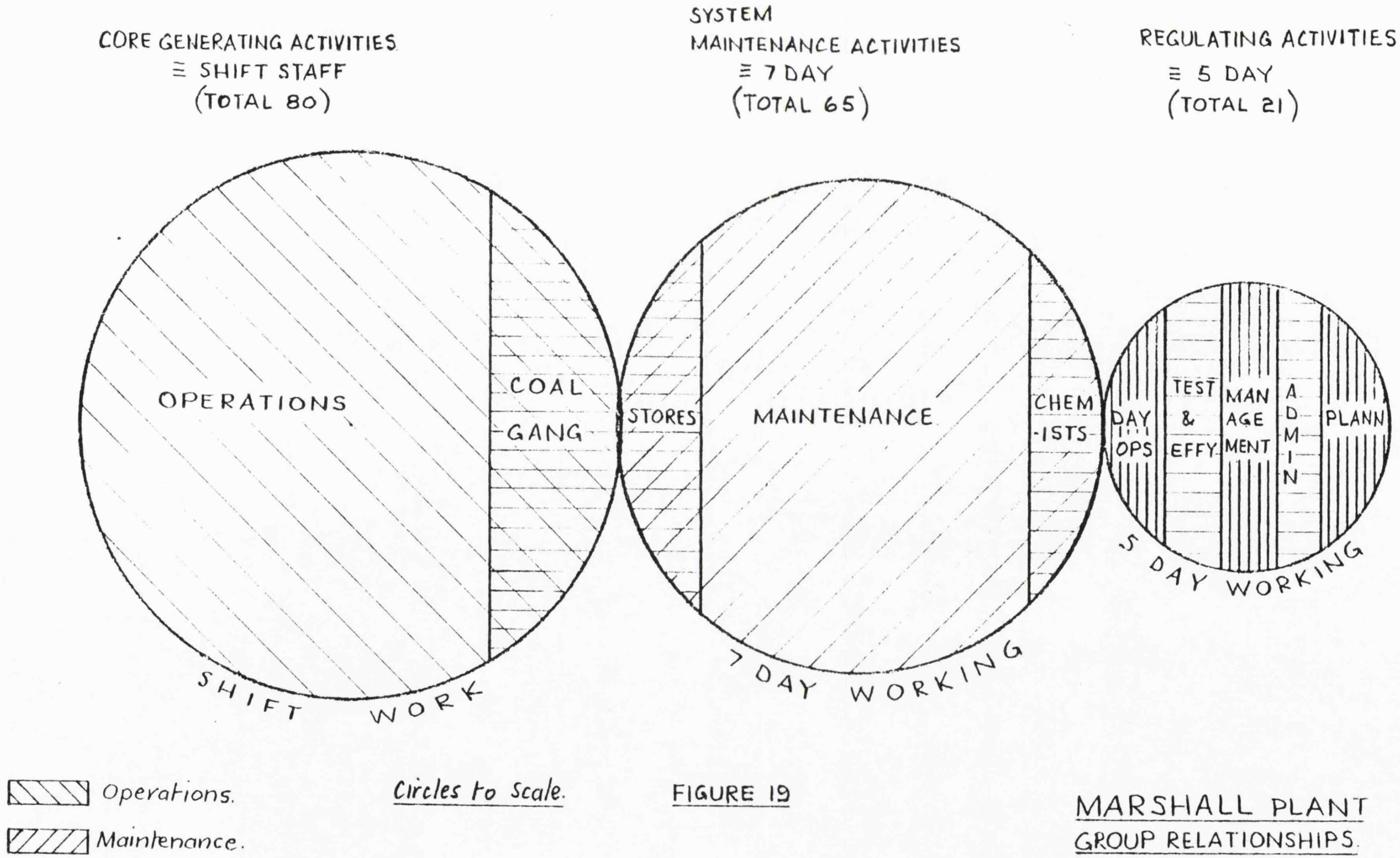


FIGURE 19

MARSHALL PLANT
GROUP RELATIONSHIPS.

Returning now to Olliton and figure 18, the large overlap between shift and seven day working implies that a majority of maintenance work is carried out on a twenty-four hour basis. This is also the reason for the shift working circle being so large because it includes a majority of the normally seven day working maintenance staff.

The overlaps and horizontal lines are the essential differences between Olliton and Marshall and each one of these features represented an organizational problem at Olliton. Most of these problems were discussed in the previous chapters but they will be briefly recalled here to make the point that the diagramatic representation shows up such organizational discontinuities.

Day production engineers The day production engineers are shown working a five day week but they have line responsibility for the seven day working production staff. If the total team comprises engineers, foremen and industrial staff then that team is either required to work five days or seven days a week. The study at Fossil Strand showed that the working patterns of the shift maintenance engineers at weekends was substantially changed as they then provided an engineering management service to the seven day staff. This disrupted their normal working patterns and if this disruption was acceptable then a fault still exists somewhere within the engineering work patterns.

Olliton chemists Figure 18 is not entirely complete since it shows the chemists dividing their time between five day working and seven day working. In fact their working patterns are five day and shift working which would have placed a small isolated group within the shift circle. This would indicate a even bigger discontinuity than the one shown and raises the serious question of the need for such shift work. Other stations similarly placed manage without shift chemists and the feeling was that it should be discontinued at Olliton.

Engineering services. The engineering services on five day working are shown removed from the production staff and having contact with them through the resources department. This would be the actual situation if the system were operated and yet the engineering services staff have the responsibility for the state of the plant.

Maintenance staff on shift The biggest discontinuity is the almost total eclipse of maintenance staff into the shift working cycle. This greatly enlarges the circle which represents the proportion of total staff working on shift. The merits of shift work are discussed in Chapter 10 but it is generally considered to be undesireable and the contrast with the Marshall diagram where no maintenance staff work shift is striking. As already discussed in Chapter 5 the practice causes serious difficulties at the station which lead to inefficiencies.

Elimination of maintenance At the Marshall plant each circle represents a clearly defined function, or group of functions. At Olliton, production spreads over two circles and implies a merging of the two separate functions.

Managers in both the American and C.E.G.B. power stations accepted the desirability of sufficient friction between operations and maintenance to give rise to applied pressure to each other. With a production system this potential conflict occurs within one department with an operations orientated head. This seems a less desirable form of organization than the operation and maintenance one where two departmental heads of equal status can appeal to the deputy or station manager when policy conflicts arise. Such conflicts will then be viewed in terms of station requirements.

The N.J.B. and N.J.I.C. division The other discontinuity in figure 18 is the horizontal line in the shift working circle. This represents a staff scale discontinuity such as does not exist in the American power stations. Although the shift engineer of an American station is classed as an engineer and may be on a different scale, he nevertheless represents the top level in a continuing series. In the C.E.G.B. power stations the line actually represents a overlap of duties with superfluous levels within the organization. It also represents multiplication of duties such as treble checking of isolations.

Areas of circles The areas of the circles in figure 19 represent the staff totals and give a reasonable indication of the staff distribution. The equivalent work area for one shift would be reduced to one-fifth (16 posts) but this argument would not apply to the seven day working since the staff presumably carry out a total workload. In the case of Olliton the circles do not represent the staff on each function because of the overlaps. However the staff figures for the main functions are shown (figure 18) and the areas of circles representing core maintenance and regulating activities would almost be in the reverse order for this station.

Summarising the diagramatic representation A considerable amount of research on organizations is designed to establish parameters relating the organizational structure to the technology. An early and significant study was that carried out by Woodward (1965) and her results showed a relationship between certain organizational features (e.g. levels in the hierarchy) and the type of technology. Later, Perrow (1967) refined her conclusion by using alternative parameters (e.g. routines). Mohr (1971) disagreed with some of her conclusions and suggested that other features such as noise level were of significance in the organizational structure. The common theme of all this research was the identification of certain organizational parameters and the careful relating of these to the organizational technology. The essential difference between that class of research and this study is that all the differences identified between the power stations have to be explained by something far more subtle than the technology.

The diagramatic representation adopted highlights those areas in the organization where discontinuities exist and has been found to match very closely with the conditions within that organization. Although the Marshall plant provides a very useful control, I believe that the representation for Olliton would give rise to the same sort of questioning without the Marshall diagram. Whether the system could be used for "temporary" circumstances in the C.E.G.B. e.g. major outages and whether it would apply to other industries might repay additional research. The existence of different organizational structures to perform a single technological function represented an ideal research medium. I would therefore suggest that such diagrams might prove to be a useful analytical tool for other organizational studies. I shall now move on to an examination of the power station organizational structure as found.

Some general structural features

Power stations are process industries by Woodwood's definition and in her research the median value of the number of levels of authority in the management hierarchy was six but the spread was fairly uniform between five and eight. The values for the power stations in this research are shown in the following table:-

Stations	Operations	Maintenance
Fossil Strand	7	6
Downton	6	7
Ash Haven	6	6
Olliton	5	5
Sequoyah	6	6
Bull Run	5	5
Marshall	4	3

TABLE 11 - LEVELS OF AUTHORITY

As can be seen there are substantial differences between the stations particularly if one remembers that the informal (actual) working procedure at most of the C.E.G.B. power stations would interpose an additional level in these figures. It should also be remembered that Downton and Marshall plants are virtually identical both in size and technology, but one has approximately double the number of levels in its organization. The two T.V.A. stations (Sequoyah and Bull Run) had an extended pyramid because of the provision of deputy station managers and deputy departmental heads in the case of Sequoyah. These latter were a commissioning phenomenon to be later phased out. The C.E.G.B. stations had deputies (except Olliton) but otherwise the pyramidal spread was genuine with between two and thirteen sub-ordinates reporting to the next level up. Thus the taller pyramids of the C.E.G.B. power stations were matched by a much broader based group of first line supervisors. For example, the number of first line supervisors at Ash Haven was approximately one hundred and thirty (includes group leaders where no foremen exist) and the figure for Marshall plant was twenty. These figures represent an approximately uniformed spread down the hierarchies (a power factor of 2.5 is approximately right). We therefore find the C.E.G.B. power stations similar to Woodwood's findings in terms of process industries but Marshall plant comes halfway between unit and mass production. There is greater agreement in terms of span of control for first line supervisors and in all the stations studied the important parameters were the number of locations to be covered and the number of different trades. Rarely, if ever, in this research was a group sub-divided with two supervisors to provide adequate cover. One interesting minor point is the change in these numbers if certain functions of supervisors are considered to be the most vital ones. If a supervisor's main role is facilitating work and monitoring it on a continuing basis then the average number of persons controlled in a C.E.G.B. power station is modest but variable. If, however, the main duties of a supervisor are to know the workforce they control so as to be able to help and direct them in the longer term then the numbers supervised in C.E.G.B. power stations can increase by a factor of five in many cases because of the different shift rotas worked. From these results it would seem as if some of the parameters used by Woodwood and others have not been relevant in the case of these power stations. I will look again at the power station organizations and try to analyse the main differences.

The United States power stations (and especially Marshall) were very basic and simple organizations comprising two main groups (operations and maintenance) with a number of regulating functions and a clearly defined task; namely to operate and carry out routine and preventative maintenance on the plant. The C.E.G.B. stations also met these basic requirements, but not so simply and they had other groups to commission, modify and improve the plant. These groups were normally a little apart from the main organization but do not preclude a comparative study.

Another point worth remembering is that I am not just comparing one process industry with another; I am comparing almost identical technical systems. In fact, it should be possible to interchange the whole of the Marshall and Downton organizations and each should be able to operate the other's plant with a minimum of adaptation. (Incidentally, such a change would make a most interesting organizational study). The other technical variations between the stations studied were relatively minor (coal stations need more labour than oil) and the nuclear stations require two additional organizational groups (health and reactor physics). It should therefore be possible to minimize the effects of technology in this study and assume that any significant organizational variations are independent of it. If any such variations are as great as those spanning the technology in Woodwood's study, then her conclusions might be attributable to other parameters. I shall look for some of these in the two approaches I am going to make, the first being the comparative bureaucratization of the organizations.

Pugh and Hickson (1968) defined five dimensions for assessing the extent to which an organization conformed to Weber's (1947) description of a bureaucracy. Many of the specific characteristics they used are not relevant for this study (e.g. marketing) because they come outside the functions of a power station. (After all, even the C.E G.B. is only required to meet the demand for electricity - not create it). I shall use their list of five variables to compare the C.E.G.B and United States power stations.

1. Specialization: Of the specialisms relevant to these organizations the C.E.G.B. power stations score much higher (i.e. have more) than the United States ones. e.g. In the C.E.G.B. power stations there are systems for training, welfare, security, maintenance, financial control and work control. In the Marshall plant only minimal (or no) equivalent systems existed.

2. Standardization: Is much more evident in C.E.G.B. power stations than Marshall (e.g. planned work routines).

3. Formalization: Is very detailed in C.E.G.B. power stations with all work and procedures being set down.

4. Centralization: In the C.E.G.B. power stations authority is centralized within the systems and committees.

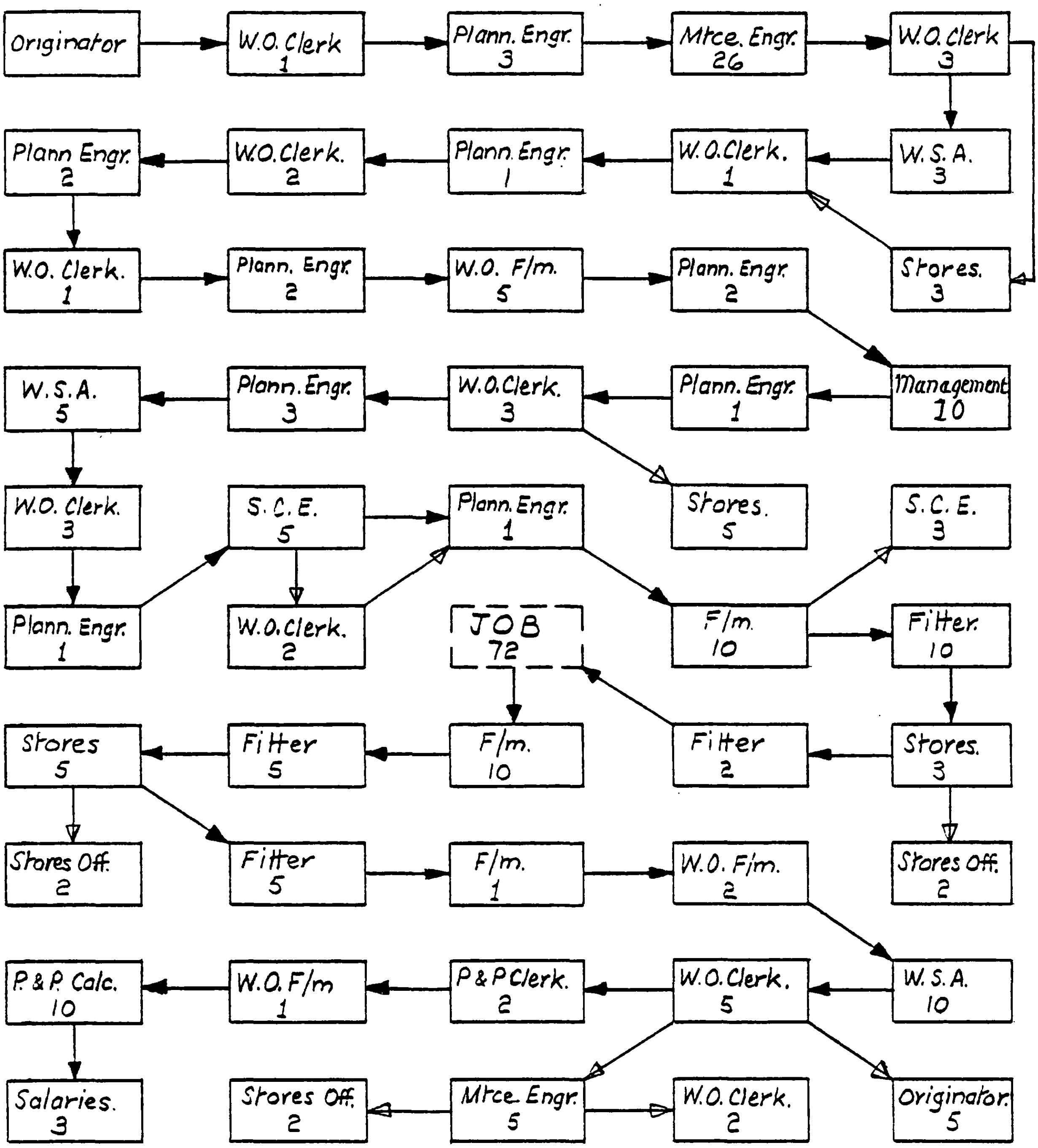
5. Configuration: As already noted, there are many more levels of authority in C.E.G.B. power stations than at Marshall.

From this imprecise comparison I am only going to deduce that on Pugh and Hickson's criteria the C.E.G.B. power stations are more bureaucratic than the American ones. I suspect that with our systems and the mass of paperwork produced, the C.E.G.B. power stations are very bureaucratic but I can offer no measured evidence to support this suggestion. (Maybe the weight of internal paper used per person per year would act as an indicator?)

The other enquiry I wish to follow is to look at the power station organizations from the open and close systems approach. The first requirement is to establish what I mean by these. Thompson (1967) defined an open system as interdependent with its environment and he classed it as "natural". But practically all systems are open by this definition. He also defined closed systems as "rational" and exemplified these as emphasising economic efficiency, planning, etc. However, Argyris (1972) took issue on these definitions and pointed to his study of the U.S. State Department (Argyris 1967) as an example of a 'closed' system which was also dependent on the outside environment i.e. open. The State Department was well aware of outside issues but was mostly concerned with matters relating to its organization. (i.e. it was introverted). My use of the terms (open and closed) is more in line with that of Argyris, namely to consider the openness or closedness of the organizational systems whilst recognizing that both types are open to the outside environment. I shall further refine the concept by considering the organization to comprise the human and administrative systems and evaluate the open or closedness in relation to its main function, namely the servicing of the plant.

In the United States power stations I would see the system as being 'open' with most of the organizational activity being directed towards the plant, i.e. task oriented. Organizational links are as informal and short as possible; e.g. direct requests from plant operators to maintenance staff for work to be done. Paperwork systems were minimised and were not normally used. The only feedback into the system was of data relating to future work required, for example, tasks that required a plant outage for their execution. Also data about the work that had been done on the plant (plant history) was prepared. This was to provide a positive performance feedback to the plant design department.

On this criterion of an open system, the C.E.G.B. power stations operated closed systems comprising a series of mostly closed loops in relation to which the plant was outside i.e. they were control (rule) oriented. Only formal links were allowed (i.e. through the paperwork systems) between the plant and the workforce. The work planning procedure (figure 12) gave some idea of this system. A job flow sheet has been prepared in figure 20 and this gives some indication of the formalized nature of C.E.G.B. power station work. This job flow procedure was for the simplest system and additional loops were required for permits etc. The time lag between the work request and the execution of the task was long unless the emergency loop was invoked. The times shown in figure 20 represent estimates based on the original scheme. Some of the times are now shorter because parts of the scheme were dropped as unworkable. The original



JOB FLOW SHEET. FIGURE 20.

Note. Diagram based on original scheme for the most simple job. Numbers are time in minutes.

Abbreviations W.O. - Works Office.
F/m. - Foreman.
S.C.E - Shift Charge Engr.
P&P. - Pay & Productivity Scheme.
W.S.A. - Work Study Asst.

idea was for the stores to have materials and tools packs prepared for the fitter as part of the planning process. A wonderful example of the inflexibility of the system arose from this when a foreman decided that six identical valves should be maintained as a block of work for one fitter and his mate. The cards were duly fed into the system and six materials packs were ready in the stores each one comprising a set of spares and a complete set of tools including a brand new sledge hammer. As can be seen from figure 20 the ratio of non-productive work to actual job time was 209:72 (72 minutes was the median job time).

Effects of the system (and other control systems) on stations varied but certain aspects were common. These will be considered next before looking at the other main features arising from this study of power stations.

General effects Some power stations tried to simplify the system and others have tried to make it work which has often necessitated further complications. The system generally demoralized the workforce by taking away their sense of involvement and much of their work discretion. In fact it de-skilled the job much along the lines of Taylor's Scientific Management theories of 1911 (1947). Some of the main principles stated by Taylor in relation to work were as follows:- Work of everyone should be planned at least one day in advance. Each man should receive complete written instructions describing in detail the tasks to be accomplished. He should be provided with the means to do his work (stores packages). If a man succeeds in doing his task correctly and within the specified time limit he should receive an additional 30% - 100% of his ordinary wages. (The maximum P & P bonus was 33%). I can only conclude that the C.E.G.B. designers of the productivity scheme (P & P) were intending to implement Taylor's ideas because the scheme follows his recommendations exactly. It is also not surprising that some of the results are predictable.

Goldthorpe and his co-workers carried out a study of the attitudes and behaviour of industrial staff which was reported in 1969. He concluded that many of the workers chose the well paid routine work in order to meet their desire for affluence. He also found that they expressed preferences for intrinsically satisfying work. Many of the industrial staff in the C.E.G.B. power stations had exchanged satisfying work (pre P & P) for the less satisfying externally controlled work under the scheme. Many had resisted the change and were even prepared to forego the bonus. They had initially experienced an increase in affluence (one third bonus) but over the years this has been eroded and they now felt (during the survey) that they were financially worse off than other equivalent workers. They had also lost their interest in their jobs.

Argyris (1972) suggested that workers such as Goldthorpe's would behave in a market orientated manner and regard work as a time/money transaction. The P & P Scheme with its eight credits per day fitted this approach and would go some way to explaining the rapid decline in morale as soon as the effect of the one third bonus was eroded. Staff turnover rates and sickness rates have increased in recent years. The sense of identity with the industry has diminished in both the industrial staff and the engineering staff. Several industrial workers at Ash Haven spoke of the sense of pride at working on the station in its earlier years but they said that all such feelings have now been totally erased.

Another general aspect of this system was the proliferation of paperwork and this led to a further system defect. It was no longer possible to progress different jobs at different rates through the system since each job on its piece of paper looked like the others. Priority therefore meant that a job had to go through outside the system. As a result, the informal work systems were encouraged and, as already explained in the previous chapters, work was sometimes done unofficially. The most important group for achieving such unofficial work was the shift maintenance team. It is also not difficult to see how such a surreptitious attitude to power station work would encourage an attitude that surreptitious private jobs would also be acceptable.

Other formalized systems existed and a departmental head gave a list of all the bodies who required details of projects and who had to give clearance before a project could go ahead. The list contained no fewer than fifteen separate groups or organizations from whom approval had to be obtained before sanction was given. This tended to apply to projects both large and small. As the departmental head said, it is far easier to do the job than to plan it.

The system appeared to be wasteful of labour and the times in figure 20 together with the staff trees would indicate that this was probably the case. The system also failed to allow for another of Taylor's principles, namely that the more times a job is repeated the more proficient, and therefore the faster, the person becomes. The C.E G.B. power station jobs all had to be timed for a slow but steady worker.

Most of the systems operated in CEGB stations were not created by them but were imposed by R.H.Q. and sometimes also implemented by them (occasionally assisted by outside consultants). However, the R.H.Q. was required to implement most of the systems as part of London Headquarter's policy. This is one subject which will be considered in Part 4 of this thesis. Before that there are several topics I wish to cover, the first one being some of the differences between the C.E.G.B. power stations.

<u>Ash Haven Power Station</u> This station tried to implement the schemes as required by R.H.Q. and of those studied probably stuck most closely to the scheme design. As already pointed out it resulted in the need for additional progress chasing groups. It was the station with the lowest morale which served to highlight a few small teams within the station who circumvented the system.

<u>Downton and Fossil Strand</u> At both these stations the scheme was operated generally in accordance with the original intentions, but with some streamlining. At Fossil Strand the centralized works office with the various trades foremen all busily co-ordinating all day long had been disbanded and each set of trades now had its own works office

which emphasised the links between work planning and the group for whom it was planned.

Olliton Reach This station had comparatively high staff levels and should have been subject to greater industrial unrest than many of the others. The reason it avoided these problems was the nature of the workforce many of whom had been drawn from the rural community and most resisted regimentation. Thus the trade union representatives found themselves co-operating with management in attempts to inform and interest the workforce. The station was also notable for having the minimum of abnormal conditions payments the battles for which are a normal subject for dispute between management and unions at most of the other stations.

Main differences between U.S. and C.E.G.B. stations

The core activity staff were similar in the United States and the United Kingdom stations, the only major difference being the existence of two classes of staff in C.E.G.B. stations. Other factors were the productivity scheme and its effects on morale.

The maintenance staff carried out basically similar jobs but it was evident that more work was required in the C.E.G.B. power stations and the productivity was lower. The other major factor was the much higher ratio of engineers in C.E.G.B. stations. The was accounted for by two factors:-

1. The absorption of effort by the planning system especially at the section head level.

2. The substantial need for continuing plant changes and modifications This absorbed a great deal of the engineer's time.

The major differences were the regulating staff, the only similarity being the senior managers. However, their duties were very different from the American counterparts and a substantial proportion of their time was spent on industrial relations problems. The majority of the remaining non technical regulating staff were absorbed as the labour force for operating the control systems in the stations.

The existence of the improvement groups had no counterpart in the overseas stations. In those stations the design and construction divisions undertook any plant modifications and certainly accepted responsibility for any plant failures. In the C.E.G.B. the Generation, Construction and Design Division maintained an aloofness from the power stations which was probably responsible for many of the failings. For example, a departmental head stated that many of the problems at Fossil Strand were centred on the mundane plant items and these problems had often been solved in previous years at other stations.

At a recent meeting between power station staff and the staff of G.D.C.D. at which a major plant modification was being discussed a project engineer (one of the most senior levels in G.D.C.D.) stated "we have no system for communicating with power stations". This was in answer to a power station request for minor alterations to the scheme which would materially assist in its better functioning. This attitude is in total contrast to the close co-operation which I found during my visit to the Marshall plant. It might also indirectly account for the long commissioning periods, the lowered plant efficiency, higher operating costs and the high levels of post-commissioning improvements in C.E.G.B. power stations.

C.E.G.B. staff levels

The existence of very large numbers of engineers in C.E.G.B. power stations had no counterpart in the overseas ones. In the American stations there were four or five qualified engineers, two of whom were the Maintenance and Results departmental heads. The others were junior engineers in the same departments who carried out a mixture of functions necessary for the power station and providing appropriate experience for the engineers. A study of the duties of power station engineers in America was carried out by Dwon (1974) and showed them as spending about 75% of their time on engineering or engineering technology. The equivalent figures for the C.E.G.B. engineers in this study were:-

Maintenance engineers	61%
Development engineers	48%
Operations engineers	48%
Planning engineers	34%

A substantial proportion of these times was spent in using engineering knowledge for such purposes as planning work. For example, the planning engineers would spend no time on resolving technical engineering problems.

The distribution of the 61% for the maintenance engineers comprised:-

Theoretical engineering	6%
Technical engineering (know how)	37%
Technician work	18%

About 60% of the N.J.B. staff possessed the H.N.C. or H.N.D. qualification and a further 20% possessed degrees. Registered chartered engineers comprised 14%,and 11% as technician engineers. In relation to their qualifications the majority of N.J.B. staff would be classed as technician engineers. This classification fits very closely with the pattern of work as shown above. The engineers have a series of grades ranging from engineering assistant, through third and second to first engineer and finally on to senior and principal engineers. They can subsequently progress to the management grades.

For the qualified industrial staff there is only one working grade, namely craftsmen. Promotion beyond this is to foreman which is the equivalent for industrial staff of the engineers promotion to management. The pay for craftsmen was virtually uniform irrespective of the trade giving the same pay rate to a rigger as to an instrument mechanic.

The differentials between the semi-skilled and the skilled are also very small. It was found in the survey that a substantial number of craftsmen had qualifications such as O.N.C. and some had the H.N.D. A number expressed a willingness to continue their studies, but could see little purpose under the present grading structure. Much of the work carried out by the craftsmen (especially electrical and instruments) was technically demanding and would have been classed as technician work.. Also many considered that much of the work carried out by the engineers should have been done by the craftsmen.

The opinion was expressed by many grades of staff (including engineers) that the promotion prospects for industrial staff were poor. We thus see a picture developing of two groups of staff doing not dis-similar work on the same plant but receiving very different rewards both monetary and in terms of future prospects. These differences were also manifest in terms of organizational attitudes with the N.J.B. being on salary and the N.J.I.C. being hourly paid. The N.J.B. had more freedom to vary their working hours than the N.J.I.C. staff. Status was also conferred by the colour of overalls or coat worn and, unofficially, extended to the dining facility at one of the stations surveyed. (Ash Haven) Many of these factors gave rise to some discontent and during the attitude survey a topic which frequently came up for discussion was the need for a grading system for industrial staff to provide better promotion avenues. The sort of scheme envisaged would give a range from unskilled staff through one or two grades of semi-skilled staff and then to the support trades. The latter would comprise the less skilled craftsmen such as riggers and laggers. The other groups proposed would comprise two levels of craftsmen (recognizing competence and experience) and two levels of technician also recognizing competence, experience and qualifications. Overlaying such a grading system would be foremen at different levels and the emergence of chargehands to take responsibility for jobs in progress. Many of those expressing such wishes also wanted to see a "run through" to technician engineers for those with sufficient competence and the necessary qualifications.

Such schemes would seem to be recognized in the continuing need for high work input levels in C.E.G.B. power stations whereas the American and French power station data would cause one to question this requirement. The French manning system was most closely in-line with the multi-grade suggestions made during the attitude survey and the duties of the American power station foremen appeared to have much in common with technician engineers. Nearly a third of the N.J.B. had previously been industrial staff (or the equivalent in outside industry) and about 40% were student apprentices trained on a day release programme.

Not surprisingly a major cause for discontent which was inherent in the grading system was the pay. During the survey carried out in 1977/78 the gross pay for a craftsman was £64 per week for a five day week. The gross weekly pay for the average engineer on site (second engineer) was £114. Many (including engineers) felt the discrepancy to be too great having regard to the typical duties of both groups. This, and certain other aspects of pay affect the morale of the industrial staff on the stations and this is the subject of Chapter 11 in the next section.

Morale and job satisfaction in C.E.G.B. stations

Many case studies have been carried out on organizations which have changed their structure or working practices in such a way as to increase the job satisfaction of the workforce. Most of these have been reported in the literature and Herzberg summed up his conclusions in a paper published in 1968. The attitude survey at Ash Haven was particularly interesting in relation to his research because many of the staff there had seen a reduction in the motivators and the hygiene factors as a result of the organizational changes introduced with the productivity scheme and a change in management with a very different management style. The previous manager had been paternalistic and, although tough and insisting on high plant standards, he was interested in his staff and knew most of them as individuals. The incoming manager was remote and was concerned with task management in accordance with the definition given by Blake and Mouton on their Management Grid (1964). He regarded men as a commodity and expected those at any level in the organization to plan, direct, and control the work of those subordinate to them. In the interviews almost all the staff expressed a preference for the former management style and only very few could recall having had contact with the new manager.

As already discussed, the work planning systems had greatly reduced the motivation factors and the work timing tended to reduce the sense of achievement on many jobs. The previous station manager had given recognition to staff members in relation to their work but this was never done by the present manager. One or two of the branch managers continued to take an interest in the staff. The general reflection by the other managers of the station manager's style was in accordance with my previous research findings on the management teams in power stations. The effect was partially attributable to a positive desire to conform and partly to the negative effect of not being vulnerable to discovery.

Ash Haven was also interesting in this research due to the existence of several groups who were placed, or had placed themselves, outside the control of the productivity scheme. In all cases their productivity was greater than that within the scheme (e.g. the coal gang) and it was noticeable that the expressed attitudes to the work and the station were much more favourable than the average for the staff. Argyris (1957) came across just such a group exercising a high level of autonomy in a middle of a large factory organization which flowed around them almost independently. He found that the motivation and work satisfaction for this group was high and that they did not seek to maximise the economic potential of their position. For the Ash Haven coal gang there was no opportunity to influence the financial rewards and the work did not offer much in the way of achievement since the purpose was to ensure a continuous flow of coal into the station. The main features of this group were a much higher level of work output, the knowledge that their part of the production process was efficient and a sense of pride in the state of their plant area.

There was also a strong sense of camaraderie within the group with the foremen being partially included. The attitudes of this group had much in common with the foundry group described in Biddle and Hutton's Tolerance Theory Investigations (1975). This foundry group had physically demanding work involving heat, noise, dust, effort and danger and similar conditions prevailed for the coal gang. The same sense of group responsibility existed and was even more marked with the coal gang because of the intrinsic nature of shift work where the following shift rely on the present shift to "play fair" and not pass on work. Similar attitudes were found in other shift groups but they were not so clearly defined because generally other factors such as work pressure were absent. The reader will recall that the shift maintenance crews at Fossil Strand were always willing to "pull the stops out" when plant demands had to be met. Although members of the coal gang often functioned as individuals (or pairs) almost the whole of the work was joined together by the physical link of the conveyor system to make them an inter-dependent group. Biddle and Hutton would argue that the behaviour patterns allowed a 'group living space' to be developed enabling the individuals, acting through the group, to feel they had sufficient control over their activities. By having such control they gained sufficient psychological space to make the job tolerable.

The important difference between this group and those shift workers at the same station who carried out the ashing duties was their freedom from the effects of the work planning system. It will be recalled that had the work planning system applied to the coal gang they would actually have done less than half as much work. And the corollary is that staff engaged in ashing use to do about two or three times the quantity of work when they existed as an ash gang having responsibility for the whole job.

Thus the work planning and timing system caused many work groups to be disbanded with the subsequent loss of their members ability to extend their personal psychological boundaries into group boundaries. The other major function of the work planning system was to substantially reduce the personal boundaries of discretion and increase the individual's work dis-satisfaction.

Similar behaviour patterns were found in the coal mine studies of Trist and Banforth (1951). Originally the miners operated as independent autonomous groups but with mechanization they were allocated jobs and periods of time during which they were to be done. Productivity fell badly as responsibility for overall production then rested with the system rather than with the miners. This phase of the work has much in common with the detailed work planning and timing of the C.E.G.B power stations. Finally, a composite system was introduced for the mining which allowed the re-creation of groups who had responsibility for ensuring that the necessary technological skills were available. This group method of working had been applied in a number of parts of the power station organization, some of the notable ones being the unit crews, the boiler cleaning crews and the ashing crews. The increased sense of responsibility and the greater psychological space afforded to the members of the composite coal gangs gave a significant increase in productivity from 67% to 95%. The substantial rises in productivity at Ash Haven have already been reported. Regrettably, the Tavistock research team were not able to gain entry into the senior levels of the National Coal Board in order that more widespread use of the research results could be made.

Problems of pay The Ash Haven attitude survey had been conducted at a time of industrial unrest directed at securing more pay and allowances for the N.J.I.C. staff. As a result, the topic of pay arose frequently during the interviews and sufficient data were obtained to justify a more thorough examination of the topic. This has been carried out in Chapter 11 and only the conclusions will be used here.

At the time of the survey the suggestion that power station shift and seven day workers were below the supplementary benefit level was regarded with astonishment. If one accepts Maslow's theory of progressive needs (1954) which start with physiological needs and progress to self actualization, and if one accepts the "unofficial" definition of the physiological needs baseline as being the supplementary benefit levels, then the evidence shows (Chapter 11) that the average pay for an industrial worker at Ash Haven (including some foremen) was below the baseline and physiological needs therefore were unsatisfied.

Evidence was forthcoming from other power stations that the situation was commonplace since many of the staff applied for certain benefits such as free school meals and they required to have certificates of actual incomes signed by the Personnel Department. These were issued at all the C.E.G.B. stations in the study but the implications didn't appear to filter up to the senior management levels or the R.H.Q.

Part of the reason for the greater upset caused at Ash Haven by the low pay situation was the uneven distribution of overtime (nearly all went to maintenance staff) and the high pay (about double) of the large contracting staff on the site.

The pay study showed the average Ash Haven staff member to be £5 per week below the supplementary benefit baseline with a disposable income of less than £35 per week. The value of a day's overtime was about £10 net so working an additional day could raise disposable income by nearly one third which was a very significant difference and made overtime very important. Many of the staff were aware of the cost of contract staff to the Board and this made the withholding of overtime even more frustrating.

The effects of the low pay (apart from the lowered morale and poor industrial relations) was a higher staff turnover particularly in those skills which were in demand such as instrument mechanics. This cost the Board a premium in the form of wasted training costs (estimated at £2,000 per instrument mechanic) and the loss of plant availability due to the inability to recruit sufficient skilled fitters. Foremen were seriously concerned at the very low numbers of mechanics who had actual knowledge of the plant and adequate experience.

Only a little information was obtained about pay in overseas power stations; in the T.V.A. a foreman's pay would be approximately equivalent to a graduate engineer with about five years experience. In 1976 this was equivalent to in excess of £200 a week gross or nearly two and a half times the salary of the C.E.G.B. foremen.

Summary of main points

In this review of the power stations I have been able to identify in organizational diagrams, some of the anomalies and problem areas in C.E.G.B. power stations. The American power station organization apparently avoided any such problems.

The study of some basic organizational parameters showed considerable variations even though the technology remained a constant.

The existence of two types of staff (N.J.B. and N.J.I.C.) caused resentments and problems in C.E.G.B. stations. The N.J.B. staff generally had the qualifications and carried out the duties of technician engineers but received pay equivalent to the national average for chartered engineers. For them promotion prospects were good with no upper limit. For the N.J.I.C. staff the only promotion prospect was to foreman. Work ranging from semi-skilled (riggers etc.) to that of technicians (competent instrument mechanics) was all paid at a constant rate and an analysis showed that at the time of the attitude survey the average pay of the industrial staff was below the supplementary benefit level and this was for working unsocial hours in the form of shift or weekends.

On the basis of parameters set by other research workers the C.E.G.B organizations could be fairly classed as bureaucratic. The systems were not flexible enough to cope with the technical demands of the plant and the productivity scheme which they supported was an example of Taylorism in a pure form.

The scheme which closely defined the time and work content for each job detracted from group working and reduced the output of staff. Certain groups outside the scheme were twice as productive and appeared to have a higher morale which may have been due to the greater 'psychological space' encouraged by their group membership. Other examples were found of a negative nature where previously effective groups had been disbanded and effective work under the scheme had plummeted.

At one of the stations the previous manager had been paternalistic but directly involved with all the staff and a new manager was mechanistic and regarded staff as a human resource. This policy also extended to engineers who were "posted" every six months without prior consultation. Morale at this station was low.

In all the C.E.G.B. power stations the total workload appeared to be very much greater than that in the American stations and this may have been due to inferior plant or badly designed stations. No close links existed between the design department and the power stations such as that found in the American stations. This is a subject I will investigate further and I will look at the reasons for the imposition of the work planning systems. These will be considered in the conclusions, but some useful comparisons will first be made between the present C.E.G.B. power station organizations, those previously existing and present U.S. organizations. Before dealing with those topics I will first complete my studies of power stations by reporting on 3 special topics concerning employment issues.

PART 3

THREE SPECIAL STUDIES OF EMPLOYMENT ISSUES

The problems and implications of shift work are studied. Pay rates for power station staff are analysed. Some thoughts are expressed on overmanning and redundancy.

CHAPTER 10

SHIFT WORK

Introduction

These first paragraphs of the introduction serve for the next two chapters also. In these three chapters topics are discussed which have wider relevance than the electricity supply industry. No doubt the conclusions of the main study will also have applicability beyond the industry.

The three chapters are complimentary to the earlier analysis and deal with problems which primarily concern the individuals within the organization rather than the corporate body. None of the studies has been pursued to its conclusion but each is of some relevance to many other industries in the U.K. All three are inter-related and two of the studies are interdependent (i.e. pay and overmanning).

The country is belatedly waking up to these problems which I believe to be some of the most important which have confronted industry in the last decade and will remain some of the most important to be tackled in the next decade. There are signs that things are changing and these brief chapters might be useful in providing some field data on the topics for other researchers.

This chapter on shift work is centrally relevant to the C.E.G.B. since a substantial proportion of the power station staff have to work shifts. The tighly staffed U.S. power stations have nearly half their staff on shift and although the proportion is less in U.K. power stations the actual numbers on shift are greater.

I shall present data and opinions on the subject from staff employed in 2 C.E.G.B. stations and review information from other sources on the subject. I shall end by proposing some possible alternatives to the present system in relation to power stations.

Power station shift working patterns

The shift work in power stations has been dealt with at some length in Chapter 5 so in this chapter I shall confine myself to providing a brief summary of the shift team duties. The shift charge engineer (S.C.E.) has responsibility for the whole station out of normal working hours. One of the assistants (A.S.C. Control) is mostly concerned with the monitoring of performance in the control room and the other assistant (A.S.C. Plant) deals with plant problems including making isolations of plant and organizing permits-to-work. In this he is assisted by two other operations engineers. The two shift maintenance engineers (S.M.E.'s) comprise a separate group, one covers the mechanical plant and the other the electrical and instrument plant. Plant problems are discussed with the A.S.C. Plant and priorities determined with the S.C.E. The S.M.E.'s organize work and sometimes use their engineering judgment as to the best way of keeping plant 'on-load'. There are two maintenance teams comprised of fitters and support staff each of which is directed by a foreman.

Each unit of plant has an operations crew with a unit operator in charge working in the control room. His duties involve the checking of conditions, taking readings and making adjustments to control the plant performance. The assistant unit operators alternate between the control room and the plant, make plant checks, take readings and make adjustments. They also lead the remainder of the team comprising auxiliary plant attendants (A.P.A.'s) in carrying out plant isolations preparatory to day maintenance work. Some oiling and greasing is done together with plant cleaning. The operations foreman is mainly concerned with directing work in the auxiliary plant such as the gas turbine house and the water treatment plant. The coal gang is physically remote from the rest of the site and the small shift team are relatively self-sufficient.

Olliton was the 2000 MW oil-fired station studied and the main difference was that most maintenance was done on shift. This gave rise to conflict requirements between the planned maintenance and a breakdown service for the plant operators.

At Fossil Strand Nuclear Station there was close co-operation between all the groups on shift but this would have been greatly enhanced had the industrial staff been on similar rotas to the engineers and foremen. The three shift maintenance engineers formed a very close group with their own mess room and the three shift maintenance foremen had a similar pattern. Some differences in the structure were occasioned by the special requirements of a nuclear plant and these are discussed in Chapter 5.

Ash Haven coal-fired plant did not have such a strongly coherent shift team because of fragmentation due to the different rotas worked by groups of staff. The operations industrial staff in two separate station groups were also on different rotas but the maintenance industrial staff shared the same rota as their foreman.

The American stations visited had very small shift crews and the size was minimized by the fact that only 4½ men are required to provide continuous manning of one post. Thus, for a single post e.g. S.C.E., 5 individuals were required, but for a double post e.g. unit operator only 9 were recruited. At the two French stations the practice was to have six shift teams giving each a spell on day work as part of the overall rota. During this period they carried out test and efficiency duties and training.

A typical five-cycle rota normally worked by engineers and foremen is shown in the table:-

Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
-	M	M	M	-	N	(N)
(N)	N	-	S	-	-	-
E	E	E	-	M	D	D
M	-	N	N	N	-	-
-	S	S	E	E	-	-

TABLE 12 A TYPICAL FIVE WEEK SHIFT ROTA FOR N.J.B. STAFF

Key: M = mornings (N) = 12 hour weekend night
E = evenings D = 12 hour weekend day
N = nights S = spare shift (day work)

One other very important aspect of shift work is that the lines of command are short and decisions are commensurately quick. Very often the foreman will get involved in a technical problem together with a fitter. There is a far more informality on shift (out of normal hours) and the planning rules and procedures are often disregarded as are many of the working practices associated with trade unionism. Many engineers and foremen were involved in practical work but it was always stressed that no shortcuts were taken with safety requirements.

Opinions about shift work

The opinions of the staff involved in shift work were only seriously elicited in the studies at Fossil Strand (nuclear site) and the Ash Haven attitude survey (coal-fired site). The data are presented separately in the following two sub-sections.

Shift work at Ash Haven One S.C.E. pointed out that to progress in the industry it was necessary to have experience as an S.C.E. on modern plant and that such a post has got to have been achieved by the early 40's at the very latest. Failing that there was a danger of remaining on shift as an S.C.E. for the rest of an individual's working life. Many S.C.E.'s believed that the commissioning delays of modern plant had seriously damaged their chances of promotion. One point often raised was the desirability of having shift rotas which included engineers, foremen and operators on a common shift team and preferably also included the S.M.E.'s staff. Several operations engineers spoke of alternative systems which they had experienced at other power stations. The majority spoke in favour of shared systems with a stronger team spirit and the ability to allocate tasks in accordance with peoples strength, weaknesses and preferences. The only adverse points raised were by some of the operators who feared they might end up with an unfriendly foreman or that favouritism might be shown under such a system. However, neither of these fears appears to have been realised by the coal gang or the shift maintenance teams where the men and the foremen work common rotas. Others said that a foreman's role was to know and supervise a group of men and this was totally defeated if they were on different rotas. The problems of amalgamating the shifts would be considerable and objections at this location were raised to the working of the "double-back" system which had been adopted by the operations industrial staff. This involved the working of an evening shift, having the night shift off and coming in for the following morning shift. The object of the system was to extend the weekend by a further half-day and it arose about one week in four. Although the practice is not altogether desirable, it is not so strenuous as working days with extended overtime in the evening.

At this location there was criticism from the maintenance fitters about the methods used for recruitment to shift work. These partly stem from the inadequate rewards for such work but most arose from the universal dislike of shift work. It was believed that the selection systems were unfair since the instrument mechanics on shift (for both stations) were drawn from the 'B' station and the electrical fitters on shift were drawn from the 'A' station. The view was sometimes also expressed that management used shift work as a threat and a form of punishment. Many of the staff at this location had a dislike of shift work which almost amounted to a dread and many would have left rather than have undertaken the duties. Under these circumstances there was a great deal of resentment against those individuals who are able to produce a medical certificate exempting them from shift work. The generally held view was that most such certificates were spurious. For those on shift, the type of work carried out was often preferred to the typical day work duties. Also, the freedom from the controls and systems associated with the day staff were enjoyed and the men were expected to exercise more responsibility on shift. Other benefits of shift work mentioned by some were the greater period of day time spent at home and the ability to do jobs about the house, to buy materials etc. No-one spoke of carrying out other paid work (moon-lighting) although some alluded to it and suggested that up to half the total number of manual shift workers had other jobs. I made no attempt to verify these data.

The biggest disadvantage of shift work was clearly the need to work nights. Many considered this had an adverse effect on their health and one operator stated that no-one had yet worked on shift until retirement and that several had died before retirement. One unit operator during the survey left for a much lower paid day job in order to come off shift. The other main dislike about shift work was the unsocial hours i.e. evenings and weekends. For married men with working wives or children at school such factors had adversely affected married life. Some older men also pointed out that when the children had left home their wives often disliked being left alone in the house at night.

A number suggested ways in which the effects of shift work could be ameliorated. It was evidently the practice of a number of firms in the area to expect routine work on night shift until shortly after midnight after which the crew were considered to be on standby and available for defects etc. Such a practice would generally allow men a couple of hours sleep, the physical benefits of which might greatly outweigh the loss of output. Although not explicitely stated by anyone, a certain amount of "resting" would seem to take place unofficially at present. Another practice of some firms was to allow men to transfer from shift to days at 50 years of age without loss of shift pay.

Most engineers disliked shift work and those that found the duties satisfying believed that a few years of the work was adequate. Standby duties (e.g. like firemen) was another alternative proposal for dealing with shift problems.

The engineers considered there was considerable overmanning of industrial staff, the example being given of five unit operators for three units on the new station whereas the common practice of other 2000 MW stations was to have one unit operator per unit and to upgrade the assistant unit operators to cover absences. Also, most other 2000 MW stations had one foreman per shift whereas this location had five (two stations). The engineers considered that the manning levels were so high that low job satisfaction was inevitable. The opinion was expressed that this was the result of weak management and union militancy. Many of the engineers interviewed commented on the desirability of coming off shift at 50 or 55 years of age and having the right to transfer to day work after a number of years on shift (e.g. 15). Several recognized that the high shift bonuses paid made leaving shift work difficult and total income would not normally be restored to that for a shift charge engineer until promotion to deputy station superintendent which is at two levels above the post of shift charge engineer.

Only one of the nine foremen interviewed at this location expressed a liking for shift work including tolerance of nights. One or two considered shift work tolerable apart from the night shift but the majority did not like shift work at all. One considered that if a rest period were possible during a night shift this would dispense with the main objection. It was pointed out that the practice in the merchant navy is to have a minimum steady state crew on duty and the remainder available on standby. The foremen considered that the financial rewards for industrial staff on shift were low and this was the cause of many avoiding shift work by obtaining doctors certificates. One foreman considered that shift work had adverse effects on health and another thought the work was particularly stressful. Several believed that early retirement or transferred to days should be a part of the shift working pattern.

About half the industrial staff on operations who were interviewed did not like shift work but the remainder tended to take the view that the advantages slightly outweighed the disadvantages. One such advantage was the ability to get things done during the day. Most of the staff preferred the idea of foremen, engineers and industrial staff all being on the same shift. Several of the staff wanted the shift system designed to give the men a period on day work. Many spoke of the desirability of finishing shift work before 65 and considered we should be like the police and services and finish shift work after 20 to 25 years.

The social links outside work varied with the different shift teams and probably depended as much on the spread of homes as on their inclination to join football teams, skittle groups etc. There were comments of a much stronger family atmosphere existing in previous power stations where they had worked. Car sharing groups also had a strong social function particularly if the group were in the habit of stopping off for a drink on the way home. One difficulty for shift staff often mentioned was the provision of holidays during the peak time in August. The men considered management were being unreasonable in not allowing some overtime to be worked during this period.

Various comments were made by some of the shift maintenance fitters including one who had liked shift work but who had come off after nine years on his doctor's advice. Many others spoke of shift work not suiting physically (or socially) saying that regular nights sleep led to greater physical well-being. It was suggested that night work and weekend work should be kept to the minimum with any requirements above this minimum being met by a call-out system. It was stated that a nearby factory allowed the shift maintenance staff to organize their own rotas. They were expected to deal with breakdowns and patrol the plant which they considered to be part of their responsibility. It was also expected that during quiet times they would have some sleep. At a large British steel plant the working of standby nights shifts was the practice and this enabled the men to relax when no defect occurred whereas in the power station the men had to keep up the appearance of working.

Most of the comments from the shift coal gang expressed preference for the old two shift system rather than the three shifts now operated. Some failed to see the need for a night shift because the heavy plant could not be used due to a noise nuisance. For the security guard the rota avoided too many nights in a row and one commented that when working only two nights it was unnecessary to have a full eight hour sleep between. Many spoke of the desirability of finishing shift work before 65 and one, aged 61, who had just come off shift had found the last two years a bit of a strain, particularly the night shift. The team spirit was particularly strong amongst the coal plant staff with a number of social activities involving the whole of the team taking place outside working hours.

Shift staff opinions at Fossil Strand As already mentioned in previous chapters, the opinions on shift work at this location were mainly confined to the electrical maintenance branch. Both the engineers and foremen spoke of the helpful and co-operative attitudes that were present and which arose because of the sense of belonging existing between a stable group of men working the same rotas. Many of the engineers considered their role as members of the station shift team with special responsibilities for the electrical maintenance whereas the shift foremen were more disposed to the view that they were maintenance foremen working on shifts. These different attitudes probably arose because the engineers main task was to solve technical problems on the plant during the shift whereas the foreman's main task was to organize and deploy the industrial staff to achieve a pre-planned work programme until that programme was varied by the S.M.E.

The fitters and mates in general did not like working shift hours and also considered the rewards for the additional burden of shift work to be unsatisfactory. However, the type of work done on shift was considered to be more satisfying than day work the reason being the increased responsibility due to a reduction in numbers of supervisory staff. Also, a more flexible approach to planning was used on shift and defect work tended to be of a more purposeful nature. Some of the surprising findings on this study were that a sense of relief and relaxation seemed to effect the whole of the shift staff as soon as the car park emptied and the station was quiet at the end of normal day working. This is not what one would rationally expect since the moment the day staff depart the shift staff have to carry full responsibility. Therefore, their relief and pleasure was either related to having a meaningful task to carry out, or it was related to the removal of the "organizational top structure" and the leaving behind of those persons directly concerned with plant operation. The foremen and engineers expressed satisfaction with the devolving of considerable discretionary powers as regards the way in which they could control the work. To a lesser extent the same feelings were displayed by the shift fitters but they were still partially controlled by the work planning and work measurement systems. All had a clear perception that what they did was immediately and directly related to plant needs.

Within the community comprising a particular shift all the foremen and engineers regarded themselves as members of the team sharing its sense of purpose and having a valuable contribution to make towards its achievement. The approach of other members of this community (shift staff) was more important to them than the approval of more remote members of the organization. They all held the parent maintenance branch in high esteem and were happy to carry out work on its behalf outside normal working hours.

At this same location an operations superintendent and an S.C.E. raised some points in relation to shift work. They considered that short-term planning should also be a shift function particularly for those jobs which were complex and had to be carefully monitored. They agreed that shift maintenance work carried out in the middle of the night was in some ways less efficient than the same work carried out during the day, but considered that the greater plant availability during the night more than compensated for this disadvantage. They thought shift maintenance work could be highly efficient until the early hours of the morning, but to expect a maintenance crew to work hard throughout the night and every night would be unreasonable and unwise. They also suggested that for any station on "two shifting" operation, maintenance work was enormously valuable during the few hours when the plant was shut down in the middle of the night. The S.C.E. also stressed the importance of maintaining good human relations on shift by walking round the plant talking to the men. The fact that operations foremen were not on the same rota as the men precluded them from becoming "father figures" and the vacuum left was filled by shop stewards.

Data and opinions from outside sources

A great deal of research has been carried out on this subject but, fortunately for me, a Government study had recently been commissioned and the report, "Shift Work and Health" by Harrington was published in 1978. This publication reviewed and evaluated papers, articles and books which were considered to make a contribution to the subject and over 140 references were listed. Harrington underlined the importance of the topic by pointing out that 20% of the workforce in most developed countries work shift. He suggested that many of those studying the subject started with the belief that shift work was unhealthy and then attempted to build up a case to support this supposition. However, he also said that many of the research projects were very thorough and produced useful evidence of the effects, or non effects of shift work. His report analysed the evidence in four chapters and then drew conclusions. The same pattern will be followed in the following paragraphs.

Early studies in shift work were primarily directed at determining the optimum length of a shift in terms of output and in several studies the reduction from 12 hour shifts to 7 hour shifts produced significant increased in output. Also short breaks every 4 - 5 hours were found to be beneficial. When the overall working hours were reduced the absence levels fell. Output was generally found to be best on the afternoon shifts and worst on the night shifts. One series of investigations found.a higher incidence of sickness on shift work as compared with day work but this investigation related to a textile mill, a foundry and a car assembly line. Many researchers have attempted to determine the optimum rate of shift rotation. Single night shifts produce no circadian rhythm changes in body temperature, these took one to three weeks. Animal studies seem to suggest that rapid shift rotation which preclude adaptation or very slow shift rotation which allowed adaptation were the best alternatives.

It was pointed out that many of the investigations into workers attitudes had been too subjective and may have begged the question. If the workers felt that shift work was bad for his health he would produce evidence to substantiate such beliefs. One study analysed the frequency of death in a population of over 8,000 male manual workers and found the death rate for current shift workers only 1½% above the average for the male population. However, most occupational mortality studies indicated death rates some 20% below the average for the male population. This conclusion was surprising as a higher than average death rate amongst shift workers might have been expected. Sickness absence was not regarded as a reliable indicator of true morbidity but the majority of the research carried out indicated that sickness amongst shift workers was not higher than day staff. Some studies showed that sickness absence was lower amongst shift workers, but some of this may have been attributable to the "esprit de corps" of shift workers. There was also some evidence to suggest that sickness absence was higher amongst shift workers during the first few years of shift work. Sickness absences were fairly evenly spread between all three shifts tending to be higher on the day of shift change. Some correlation of sickness rate with the worker's like or dislike of shift systems was found. A number of studies have been carried out to measure the physiological rhythms, the commonest being of body temperature. Relationships have been noted between sleep, performance and body temperature and under normal living conditions body temperature peaks in the late afternoon and is at a minimum in the early hours of the morning. Shift workers generally only flatten these differences which might suggest some inevitable peaks and troughs of output related more to the time of day than to the stage of the shift. However, other research raised doubt about this conclusion and other studies indicated that introverts might have morning work peaks and extroverts have night work peaks. It was not however possible to draw conclusions about the relative adaptability of introverts and extroverts to shift work. Other studies showed considerable metabolic alterations when comparing night work to day work. Some of these suggested that increased energy expenditure was required for work carried out at night as compared with the same work during the day. Harrington concluded that many more studies were required in this particular area.

Research on sleep characteristics has not been very helpful in terms of shift work since soundness of sleep carries little scientific basis. There appears to be a tendency to compensate for loss of sleep during some shifts by sleeping longer at other times in the total shift cycle. The mean duration of sleep during night work cycles was generally significantly less than at other times. This loss again was generally made up e.g. at weekends. Another problem associated with sleeping was the difficulty of day time rest under conditions of noise, daylight and poor housing. It was suggested that these factors might be lessened by moving away from the 6 o'clock morning start perhaps to one of 4 o'clock. Performance and output were closely inter-related with the effects on sleep and a great deal of research was done into error rates, accidents and performance. Some research indicated that night shift was the most fatiguing and afternoon shift the least and one researcher suggested this was because afternoon shift provided the best conditions for sleeping. Losses in efficiency also appeared to be related to the nature of the work and were much less if the work was non-repetitive. One very interesting study supporting this was to measure the delay in answering telephone calls, these delays were found to be the least in the late evening and longest during the night. It was found that increasing the workload reduced the delays. Several studies have shown that error rates are greatest at 3 o'clock (both morning and night). These error peaks were most noticeable if they occurred towards the end of a shift. Several research projects indicate a general conclusion that accidents occurred at higher frequency during the night shift. The short cycle shift working minimized the temperature adaptation and this probably prevented performance adaptation as well. It was also found that individual motivation had a considerable effect upon performance.

Much of the research on the health effects of shift work has centred on the nervous disorders and gastro-intestinal disturbances. It was pointed out inferior catering arrangements are often made for night workers which contribute to upsetting their dietary pattern. One study showed that night workers eat no breakfast and 11% took no lunch. Even though conclusive evidence emerged to show that a high incidence of gastro-duodenal ulceration to shift workers, one interesting research project showed thatex shift workers had nearly twice the incidence of ulceration compared with shift workers. Harrington concluded that shift work was not conducive to good ulcer management because of the irregular hours and disordered meal times and a general tendency towards somewhat higher ulceration on shift. He suggested that better catering facilities might improve the situation.

No conclusive evidence has been found to indicate that shift work has any appreciable effect on cardio-vascular disease. Some studies on neurological and psychiatric disorders indicated a tendency to a lowering among shift workers which one researcher put down to the "esprit de corps". Forex shift workers there was a high level of disorder but this could be due to the inability of some individuals to adjust to the extra rigors of shift work. It was recognized that shift work induces a greater fatigue than day work and no evidence has been produced to link the effects of fatigue to psycho-neurotic disorders.

Some experiments on animals indicated a slower temperature curve adaptation with advancing age but no longitudinal studies have been carried out on shift workers. Most researchers believe that age would lead to an increased intolerance of shift work from the knowledge that sleep deteriorates with age and the increasing risk of morbidity and mortality obviously associated with age. Thus shift work might be expected to adversely affect such age related diseases. It has been found, however, that young people are often intolerant of shift work although this is probably due to social, family and marital privations. Such workers often take longer than the approved breaks plus random stoppages. As a result, some researchers have proposed that shift work tolerance would be considered to be poor in the young due to social factors, best in the middle-aged when adaptation has taken place and becoming poorer again in the older group. However, the studies have shown that day workers have more days off per person per year than shift workers in all age groups. Not many studies have been carried out on the effects of shift work on women, but no evidence has been produced to show that they are effected differently from men. Shift work could be a problem for certain groups of individuals e.g. Muslems whose religion requires them to fast between sunset and sunrise. Thus shift work could indirectly lead to adverse physical effects.

Shift work is often undertaken by young family men needing extra cash and the same reasons would frequently cause such persons to undertake a second job (moonlighting). Some estimates are that 2 million workers in the U.K. have second jobs and some French estimates indicate that a third of night workers in France had second jobs. Thus the extra strain of second jobs might inflate the morbidity recorded as being due to shift work. Community life is geared for the light/dark cycle and people working out of phase with this would suffer inconvenience. With such families, a wife will have to carry greater responsibility for the children; entertainments and social contacts are more difficult and sexual relations are strained. Although afternoon shift is the most desirable in the context of work, it is the most damaging socially and greatly reduces the time spent by the worker with his children. Morning shift is quite obviously the best but the early start precludes late nights.

Shift work will often frustrate a worker's desire to join in social and community functions such as sports clubs etc. A number of studies have been carried out on the attitudes of shift work both by the workers and their wives. Many of these studies were of the "self fulfilling prophecy" type but in some, care was taken to be as objective as possible. The afternoon shift appeared to be the most disadvantageous to social and family life and permanent night workers had their greatest difficulty in fulfilling their role as sexual partners and protectors of wives. One conclusion reached was the marital happiness was crucial to enabling shift workers to live with their work. They took the view that the demanding nature of shift work would probably more rapidly break up unsatisfactory marriages. Certain groups of workers find shift work advantageous as these are the solitary ones, the survivors or adaptors. Such persons would have the preference for their own company, be strongly orientated to a closed family unit or prefer solitary recreations. The advantages of frequent short holidays (blocks of 4 days off every five weeks in the C.E.G.B.) would outweigh many of the difficulties of shift work. Data on the opinions of shift workers seemed to depend on the background to the particular investigations. Many such investigations arise as a result of a decision by an organization to transfer to shift work and opinions might have been canvassed both before and shortly after the introduction of the system. In organizations where shift work is the norm (e.g. oil refinery) the majority of workers appeared to prefer it. Such workers are clearly "survivor" groups. Most studies find the majority preferred day work to shift work. Rapid rotation shifts appeared to be preferred to weekly rotation ones. It might be summarized that between a quarter and a third of shift workers do not like the system, the majority tolerate it for various reasons and perhaps as little as 10% actually like it. Harrington strongly recommended that workers should be encouraged to participate in the design of shift patterns and made aware of the consequences of the adoption of particular systems. He also recommended that employers provide better facilities for shift workers particularly those on night duties.

Proposals have been made for reducing the effects of shift work and some which should be seriously considered are to vary the changeover times. The main considerations are the fact that night shift is the most fatiguing and afternoon shift the least fatiguing. The social effects of such changes would have to be carefully considered. Advantages would be gained by stablizing nightwork for a long period and allowing the circadian rhythm to adjust. However, to have any effect a worker would have to remain on nights without any breaks for the full period. Since this is impracticable the more desirable alternative is the rapid rotation system involving changes every two or three days. One solution to be considered is to endeavour to find a small group of volunteer permanent night workers. For such workers, special incentives could be provided such as suitable housing and adequate pay. Harrington suggests a need to assess the job and avoid night work if feasible. He also suggest the need to allow more breaks in night work and to restrict repetitive boring work during such hours. Whenever possible, shift workers should be selected and those with pre-dispositions to certain illnesses should be dissuaded from taking up shift work. Some education of the problems associated with shift work should be given to the staff in particular in relation to eating and sleeping habits. Transfers to day work should be made as easy as possible. Whenever possible, such transfers should allow them to maintain their earning potential. The foregoing summarizes the findings of Harrington in his review and all the research relating to shift work. In the next paragraph his main conclusions are summarized.

He concludes that nightwork is unlikely to diminish in the country in the foreseeable future. No evidence exists to suggest that an excess mortality results from such work. Sickness absence is generally lower amongst shift workers and this may not be related to actual sickness. There is no reason to believe that shift workers are less healthy than day workers. However ex shift workers tended to be less healthy than those who continue on shift. "Poor adaptors" should be identified and discouraged from taking up shift work. Shift work (particularly night shift) disrupts the biological rhythms; sleep deprivation occurs in shift workers and permanent night workers seem to adapt better than those who only carry it out intermittently. Repetitive work on shift is more likely to cause accidents particularly on nights. The appropriate use of work breaks can reduce such effects. Gastro-intestinal disorders appear to be linked to shift work. Night shift appears to be the most tiring time to work. Shift work is generally unpopular and night shift in particular. Good housing, small families and a happy marriage would seem to be a pre-requisite for night shift work. Harrington finishes his review by stressing the need for more research into the problems of shift work and particularly longitudinal studies into the long term effects.

Since the publication of Harrington's review some further research has been carried out and Smith at Bradford University has carried out research which indicates that a shift worker's body adjusts fairly rapidly to the changing work programmes. This is based on measurements of sleep patterns and suggests that the REM sleep sequence would simply take place earlier in the sleeping pattern of a night shift worker whereas for a normal day worker it takes place towards the end of sleep. The situation would be very different for a person transferring to a different time zone as this would necessitate a "body clock" adjustment of the type not necessary for shift work. The research of Smith is being extended by taking body measurements on shift workers for extended periods of time.

Discussion and Conclusions

The problems associated with shift work for power station workers could be broadly divided into short-term and long-term. This division roughly coincides with operations and shift maintenance although the maintenance practices at stations vary widely. Although this division is not absolute it forms a useful basis for analysis.

Short-term problems At most of the power stations analysed the maintenance practice is to have a small (and sometimes minimal) team available to deal with defects as they occur. In the American and French power stations these problems are dealt with by the use of a "call out" system and shift maintenance is avoided. One senior maintenance engineer at a power station expressed the view that for base load plant,a two-shift cycle would be adequate thus avoiding the night shift. Most of the research indicates that the night shift is the nub of shift work problems and that without this shift the only difficulty is the unsocial hours worked. This was highlighted by the attitudes of the coal gang who knew that their plant was designed to operate on a two shift basis and that three shift working was a form of "cover up" solution to another problem. The practice of carrying out all maintenance on shift (Olliton station) meant that much of the work done on shift could equally be done as day work. Since a great deal of maintenance is of the preventative type which was classed as "dull and uninteresting" by most of the staff interviewed, much of the night shift worked must be associated with the situation found by research to be conducive to errors, accidents and low output. Thus, two reasons exist for avoiding routine work on night shift.

For industrial staff, the pay differential between shift work and seven day working was less than £4 per week gross which offered little inducement. This also applied to the foremen, but for the engineers the difference between shift work and five day working was considerable (21%). Because of the lack of inducement, coercion was allegedly used at least on one station and the requirement to go on shift was one of the greatest fears of the staff and became the main topic of conversation when it was known that additional members were required. Ways of ameliorating the effects of shift work in the short-term will be discussed together with those relating to "long-term" shift work.

Long-term shift work This form of shift work is a fundamental requirement for the operation of power station plant on base load. The majority of operations staff in power stations work shifts and such shift work for them becomes a career. Some engineers progress from shift charge engineer to management levels in power stations and although the numbers would be limited, such opportunities for progress may be a major motivating factor in the decision to take up shift work. Another factor is the substantial shift enhancement pay increasing overall pay by nearly a fifth. For the industrial staff a promotion avenue is opened from unskilled grades and progressing to the equivalent of craftsmen grades and then on to chargehand type posts and foremen grades. In the American and French power stations the progression would continue and includes the engineering grades.

Amongst the staff it was not surprising to find a few who liked shift work and the figure of 10% found by Harrington could generally be considered applicable to this research project. However, a substantial majority did not like shift work and this feeling particularly applied to the industrial staff. One major difference between the C.E.G.B. power stations and those overseas was in the manning levels on shift. A reasonable match existed for the engineering grades but much larger numbers of semi-skilled and unskilled staff were present in C.E.G.B. power stations. Since these people are likely to be carrying out uninteresting and routine work, their dislike of shift work would also fit in with the findings of Harrington's research.

A strong sense of team spirit generally existed amongst shift members and some of the joint social activities may have been a compensation for the loss of certain outside social contacts due to the nature of shift work. It was also evident that lateness and absence were less of a problem because other shift workers were directly affected rather than the remote organizational "them". The discussion also indicated that scroungers were dealt with directly by their work mates within the closer communities of shift work.

Many of the discussions with long serving shift members indicated a generally increasing desire to give up shift work as they became older. (There were one or two notable exceptions.)

Possible solutions

In the past, power stations have moved from base load to two shifting after a period of approximately 10 years. Nuclear power stations were the first exception and these are likely to remain on base load until final shutdown. Two shifting still generally involves substantial amounts of night work and can even lead to an increase in maintenance night work due to higher plant availability. However, there is is limit to the amount of maintenance work required to be carried out on shutdown plant and most members of the C.E.G.B. still believe that the currently commissioning plant will eventually become reliable. Perhaps the need for shift maintenance should be re-considered and the ways in which overseas power stations avoid it should be studied. Maintenance teams for major outages would then become a group of individuals accustomed to working night shifts since at all times outage periods need to be minimized. The U.S. major maintenance crews interestingly only worked twenty hours per day (ten hours for each of two shifts including overtime). Premium shift pay plus mobility allowances and overtime would be a part of the pattern of such centralized shift teams visiting stations in succession. On the operations side a need for much of the routine work should be questioned such as the need to clean plant in the middle of the night. Either such work should be given to a separate group e.g. cleaners or day operations crews should be created which should also serve the purpose of providing alternative day work for some of the operations staff.

Most people would not consider working shifts to be a reasonable alternative for a pay enhancement of approximately £2 per week net. Very often, more than this is required to cover the additional travel expenses involved because of the smaller numbers travelling to particular destinations from any given shift group. i.e. There are more cars with single occupants among shift workers than among day workers.

The evidence suggests that it becomes increasingly stressful to work shifts as a person becomes older. Also, as the financial advantages becomes less valid for older men, social disadvantages become more prominent. Many younger men in power stations take outside part-time jobs when working shifts. One final factor for older men is the rightly felt concern for leaving a wife alone at home and especially so if the wife is suffering from ill health. The incidence of ill-health for women is probably high in the 45/55 age group.

One alternative for shift workers is to offer the opportunity to retire early. Other organizations such as the armed forces have to face up to this situation. A scheme crediting 1½ years of service for every year's shift duties would enable men who started shift work early in their careers to have earned full pension rights by approximately 45/50 years of age. Many local firms were quoted in the research project who offered early retirement or transfer to day work for their shift staff at 50/55 years of age. Other alternatives proposed (and operated by other companies) are the creation of standby shifts where, for a period of the night, only defects were carried out. It is evident from the research that at some of the C.E.G.B. locations such patterns of work are unofficially practiced. It was evident that the mess rooms for the different grades of shift staff tended to be treated as sacrosant when going upwards in the hierarchy and were recognized by the more senior groups as being places where the particular individuals could be found in the event or urgent work being required. One foreman said he liked such a system because when an urgent job was required he knew he could find the men in the canteen and could rely on them to "pull out the stops" and solve the problem. The head of this department was unofficially aware of the situation and gauged the effectiveness of the staff by their overall performance and the plant availability. The cheapest way of providing such a standby is to follow the practice of the French and Americans and pay for call-out shift maintenance.

The problems are very real and the C.E.G.B. being a permanent shift worker user should thoroughly investigate the alternatives to the present less than satisfactory system.

CHAPTER 11

STUDIES AND DISCUSSION ON PAY

Introduction

All the information from power station staff was obtained during the attitude survey at Ash Haven. With the exception of the administration staff, a representative sample of all the staff on the site were interviewed (over 180 interviews). These interviews were unstructured, but pay and related topics were often discussed and this information, together with factual information about pay rates, is presented in this chapter. The study took place during the financial year 1977/78. A review of the data obtained is presented in the first section of this chapter and the following sections will summarize this information, offer some worked examples of pay rates and discuss the overall findings.

The interview data

For analytical purposes the staff interviewed during the study were slotted into six groups which related to particular departments, status groups or groups doing similar work.

The engineers Of the twenty comments on pay by engineers none were critical of the N.J.B. rates and five commented that the pay was good. The only qualification was that at higher staff levels the pay rates tailed off and that senior staff were badly paid. Several engineers (all working shift) considered the shift bonuses were too high. This caused problems of getting off shift work. Most of the comments by engineers related to the industrial staff pay. One thought there should be greater equality of pay between the industrial and engineering grades and another criticised the disparity between the industrial staff pay and the equivalent contractors rates which were approximately double. Others considered that craftsmen's skills should earn differentials. It was also suggested that the industrial staff shift bonuses were too low.

Foremen's comments Over 20% of the foremen on the site were in fact interviewed and eighteen commented on pay. One of these thought the pay was reasonably good and one or two others were not dissatisfied but had some reservations. Most considered the rate for the job to be considerably less than was paid by other comparable locations. Many considered the industrial staff pay was too low and said that contractors found ways of circumventing the Pay Boards by offering lodging allowances etc. The differentials between mates, fitters and foremen were considered to be too low as were the shift bonuses.

Operations industrial staff None of the twenty-eight commenting considered that pay was adequate although four considered it was reasonable. Even these declared that the shift bonus was inadequate. A third considered the pay to be poor and a similar number thought that low pay was a major cause of discontent. The lack of overtime for this group was another major cause of discontent and some staff had transferred from operations to become day cleaning staff and found they could earn much more this way with overtime. It was stated that some of the operations staff took up supplementary benefits as their pay was below the minimum levels. Some of the major outgoings for these staff were the cost of travel (including car ownership) which varied from £8/£12 per week. The cost of housing was in the region of £9/£12 a week. The take home pay for A.P.A.'s was in the region of £52/£54 a week. This left net disposable income (net pay minus rent, rates and travel) in the region of £32/£34 a week. Some said that at a similar nearby process chemical plant the equivalent of A.P.A.'s obtained £10 a week more for shift work. One member also pointed out that power station workers were now nineteenth in the industrial pay league.

Mechanical maintenance staff Nearly all this group of thirty commented on the pay and eleven considered it to be reasonable.

However, some of these eleven were special cases being either single or in receipt of services pensions. Those working shift also considered the shift allowance to be derisory and many considered the pay to be slipping behind that of other industries. Many pointed out that the total pay was equivalent to that obtained fairly generally in the area. (N.B. All the staff worked three weekends in every four.) They were also very conscious of the fact that contractors were generally earning more than twice as much as the average station staff. One (living in a farming community) said that most of the farm labourers were better off than the power station staff. Other comments were that the special rates for unpleasant jobs (A.C.M.'s) have remained unchanged for several years and were totally inadequate, the example of 6½ pence per hour for working on the dust plant was given. For this group, the average take home pay appeared to be higher than for the operations staff because a certain amount of overtime was available. Figures of £60 a week net appeared to be typical. Examples of travel and housing costs were similar to those for the operations staff.

Electrical and instrument staff Of the twenty-seven participants, twenty-five made comments. Nearly all thought the pay was poor or even very poor and only one thought it was reasonable. Again, the comments were that the total pay was average for the district for a five day week. Also, for power station staff, travel is generally an additional financial burden. The gross pay rates for other process industries in the area were given and the figures bore out the allegation that C.E.G.B. rates were about £10 a week lower. (Table 13)

Location	System	Basic Pay £	Extras
British Steel	5 day week	77	-
B.P. Chemicals	5 day week	73	Non Contrib. Pension
Skill Centre (Training)	5 day week	54	Free Meals
Fords Swansea	5 day shift	76	Low cost cars
C.E.G.B.	7 day working	74	-
C.E.G.B.	Shift working	78	-
British Steel	Shift working	97	-

TABLE 13 - COMPARATIVE PAY RATES

Other criticisms by this group were that differentials should be increased and the A.C.M. payments also needed increasing. Five quoted their take home pay figures, the average being £55 and all quoted their mortgage costs and travelling costs. The costs of these together range from £25 - £35 a week leaving net disposable income as low as £21 a week. One pointed out that new semi-detached houses in the area started at approximately £14,500. One was about to depart for Saudi Arabia where his basic pay would be £10,500 a year but with overtime would probably be £20,000 (tax free).

Coal, ash and other groups Within this group a substantial number considered the pay to be reasonably good although all thought shift pay was poor and most considered the A.C.M. payments were poor. All recognised that the contractors earned very much more money and that the rates in other industries for a five day week were comparable. Pay slips were produced by several in this group and these, together with facts about their circumstances, confirmed that the net disposable income was as low as £23 a week for a married man. Within this group most did not work overtime nor did they receive craftsmen's pay rates.

Summary of the data

It was evident that most people's concern about pay was in relation to their take home pay. Those who mentioned it said that the basic pay rates was extremely low, but pay was considered to include the normal bonus plus the payment for particular working patterns. On this basis, flat rate pay would consist of basic pay plus seven day working allowance plus the full bonus. Probably half those commenting expressed general views that this pay was reasonable for the area but many pointed out that the equivalent pay could be earned elsewhere for working a five day week. Since most people disliked working weekends or shifts they expected financial compensation for such requirements and on this criterion they considered their pay to be poor.

The other main area of comparison was with contractors, five hundred of whom worked on this site. It was generally considered that contractors were entitled to some extra pay due to the impermanent nature of their work but the comparative permanence of the contractors on the site significantly detracted from this argument. Figures put forward for contractors net pay varied from £100 to about £130 (occasionally much more) but some of this was acknowledged to be due to overtime. The general conclusion was that the differential between the station and contractors pay was too great.

Various minor points were covered, one suggested that all differentials should be greatly increased starting with a substantial pay rise for the senior managerial staff. The general pay trends over the years were outlined and were considered to be poor until the advent of the productivity scheme which put the C.E G.B. staff ahead of the local firms. Since that time this advantage has been gradually eroded and now the pay rates are rather less than those of competing industries. One considered that the shift pay would be equivalent to the seven day working pay if allowance was made for the bank holiday additional payments made to the seven day staff. One welder claimed that his take home pay only exceeded that of a farm labourer (traditionally the lowest paid workers) by £5 a week. Overtime rates were criticised by a number of staff because they were based on the flat rate of pay in 1974 (four years before).

Establishing pay rate facts

I tried to establish some comparative facts and data based on the information obtained from the Department of Health and Social Security and the Government's statistical publication (Social Trends 1977). For this exercise four types of N.J.I.C. posts were used and these were chosen to represent median salaries for many of the groups of staff on the station and ones to which other posts could easily be related. The foreman chosen was Foreman Grade 1 which covered the majority of foremen. The next post chosen was that of craftsman and the basic pay of unit operators and assistant unit operators is roughly comparable. The next was that of A.P.A. and some others such as drivers and shunters have similar basic rates. The last group chosen were labourers and their rate of pay is the same as that of cleaners and assistant storekeepers and not too far removed from the basic rate of mates.

Table 14 shows how these four basic pay rates become the gross pay rates both for shift work and seven day work (with the appropriate frequency of weekend working). It will be noted that the pay rates under phase 1 and phase 2 of the Government's Income Policy were not a part of basic pay and bonuses were not calculated on present pay. These examples of gross pay were compared with the average gross pay for the full financial year for all the industrial staff at this location. The figure was derived by dividing the gross pay figure on the payroll by the number of staff in post for each of the 52 weeks in the financial year. The resultant value, which included all overtime, A.C.M. payments etc. was £75.27. This was thus very near to the gross pay for a craftsman working a seven day week pattern.

The comparisons with the pay of other industries working a similar pattern, such as the British Steelworks have already been given in Table 13 and indicate substantial increases in payments for shift work or parity of pay between the C.E.G.B. seven day working and their normal five day patterns. In the case of one, B.P. Chemicals, several mentioned the fringe benefits provided such as non contributory pension schemes generally regarded as equivalent to an additional £4/£5 net. Other benefits were a very low cost canteen and subsidized mortgages. At B.P. a foreman's pay averaged £135 a week.

It was interesting to notice the varying attitudes of the different groups; the operations industrial staff were the most discontented with their rates of pay. This undoubtedly arose from the low differential between the seven day working pay and shift pay and also the inability of the staff to supplement their pay with overtime working. The maintenance staff were contented with their pay although the instrument mechanics in particular were well aware of the greater rates of pay

TABLE 14 SOME TYPICAL EXAMPLES OF N.J.I.C. GROSS PAY

	7 Day Working Patterns			
Weekly Rates	Foreman 3 in 4	Craftsman 3 in 4	A.P.A. 2 in 3	Labourer 2 in 3
Schedule Salary	54.64	45.03	39.85	36.16
7 day working Payment	1.30	1.30	1.15	1.15
Prem. Allowance	12.30	10.14	7.98	7.24
Bonus 27 1/3% x 40 hrs	12.13	9.65	8.58	7.90
Phase 1	6.00	6.00	6.00	6.00
	86.37	72.12	63.56	58.45
Phase 2 (5% = Min £2.50 max £4.0)	4.00	3.61	3.18	2.92
	90.37	75.73	66.74	61.37

	Shift Working			
	‡Foreman 3 in 4	Craftsman 3 in 4	A.P.A. 3 in 4	Labourer 5 Day Working
Schedule Salary	54.64	45.03	39.85	36.16
Shift Payment	3.81	3.81	3.81	
Prem. Allowance	12.30	10.14	8.97	
Bonus 27 1/3% x 40 hrs	12.13	9.65	8.58	7.90
Phase 1	6.00	6.00	6.00	6.00
	88.88	74.63	67.21	50.06
Phase 2 (5% = Min £2.50 max £4.0)	4.00	3.73	3.36	2.50
	92.88	78.36	70.57	52.56

* (3 in 4) and (2 in 3) refer to the weekends worked
Bonus based on 1974/5 basic salary
‡ Working 3 shifts on a 4 cycle rota.

obtainable elsewhere. Foremen often had a concern for rates of pay in general (and some engineers) and their main concern in relation to their own pay was the low differential between it and that of craftsmen. Groups such as the coal gang were concerned about such anomalies as the 30p a week net extra for working night shifts (above the two shift pay rates) and the low A.C.M. payments for very dirty conditions.

Many analyses were given of the way in which net pay was used and a number of examples of net pay were between £50/£55 a week. From this the cost of travel had to be deducted and this ranged from £6 to £20 with an average figure quoted of £12. Rents and mortgages also spread over a wide range, the typical figure being £12 a week which normally included rates. Thus the average man claimed to have rather less than £30 net disposable income. Some alleged they would be better off on social security. Others said they couldn't possibly manage unless their wives were working.

My calculations to determine the net disposable income were carried out using the four typical examples namely:- foreman, craftsmen and labourers working the appropriate seven day patterns and the A.P.A. working shifts. These examples are worked through in Table 15 and for each one, five different sets of family circumstances have been chosen. The appropriate annual tax allowances have been converted into weekly figures and these are shown in column 2. Columns 3, 4, 5 and 6 showed resultant pay after the deduction of national insurance contributions and tax. No allowances have been made for overtime, A.C.M. payments etc. and no deduction made for superannuation contributions except for the foremen who were all members of the Board's superannuation scheme and with a gross pay of about £90 a week the superannuation contribution would have been in the region of £6 gross equivalent to £4 net. This has been allowed for in the table by deducting a further £4 a week from the foremen in the net disposable income column. It is probable that the deductions for the other people exceeded the additions because the average net pay for all the N.J.I.C. staff derived in a similar manner to the gross pay amounted to £53.96 per week which is less than would have been expected from a gross pay of £75 a week.

EXAMPLES & STAGES	FACTORS	FOREMAN 3 W.E in 4	CRAFTSMAN 3 W.E in 4	A.P.A SHIFT	LABOURER 2 W.E in 3	SUPPLEM BENEFIT	1.2 x S.B.
1	2	3	4	5	6	7	8
Gross Pay	Weekly	90.37	75.73	70.57	61.37		
Deduct N.I Contribution 5.75%	Tax	5.20	4.35	4.06	3.53		
Gross Before Tax	Allowance	85.17	71.38	66.51	57.84		
Net after tax. Single Man	18.17	62.39	53.29	50.07	44.35		
Net after tax Married; Child 3	31.75	67.01	57.91	54.69	48.97		
Net after tax Married children 12, 15	36.37	68.58	59.48	56.26	50.54		
Net after tax. Married children 3, 9, 11	38.96	69.46	60.35	57.14	51.42		
Net after tax. Married children 8, 11, 14, 16	44.15	71.22	62.12	58.91	53.19		
	ǂ Deduct						
Net disposable Single Man	16.00	*42.39	37.29	34.07	28.35	14.50	17.40
Net disposable Married Child 3	21.00	42.01	36.91	33.69	27.97	28.53	34.24
Net disposable Married Children 12, 15	19.50	45.08	39.98	36.76	31.04	39.55	47.46
Net disposable Married Children 3, 9, 11	18.00	47.46	42.35	39.14	33.42	42.08	50.50
Net disposable Married Children 8,11,14,16	16.50	50.72	45.62	42.41	36.69	55.90	67.08

ǂ Deductions reduced by child allowance = £1.00 for 1st and £1.50 for subsequent

* Foremen pay superannuation as a group, therefore an additional £4 has been deducted.

TABLE 15 TYPICAL EXAMPLES OF NET PAY

The average value of rents and rates or mortgate paid by those interviewed was £12 a week and the average total cost of travel was considered to be £12 a week. However, the author analysed the distances travelled by the staff at this location and calculated the likely weekly cost of travel based on typical values for car running costs. The value chosen was £10 a week and the calculations showing the derivation of this figure, together with a discussion on the problems of travel, is considered later in this section. These total deductions of £22 a week have to be offset by additions equivalent to the child benefits payable. One modification was made for single men for whom only £6 a week was deducted in respect of rent, rates etc. It must be emphasised that the figures worked are median examples and some men's net disposable income would be significantly lower than the values shown and particularly so if superannuation contributions were made of the order of £5 a week gross.

It was also said that if a man worked a day's overtime the increase in net disposable income was in the region of £8/£10. For someone with high overheads such as a mortgage such an increase would be very significant. The average overtime rate at the station during the year was found to be under 5% which would have given an average increase in net disposable income of about £2 a week. However, most of this overtime went to the maintenance and site services staff.

Alongside the net disposable income figures are shown in columns 7 and 8 the supplementary benefits payable for the same family types. Also shown are the values equivalent to 120% of the supplementary benefits since these values were used in Parliament for comparisons with the net disposable income of employed persons. (Some M.P.'s considered an employed person should be at least 20% above supplementary benefit level.) Also shown in the table are two hatched blocks of figures and those framed in a solid line are the pay rates which are below the supplementary benefit levels for the equivalent family status. Those outlined by the dashed line are the equivalent pay rates comparable with 1.2 times the supplementary benefits. The inference of these figures is that those people whose net disposable income came within the solid box would have been financially better off drawing supplementary benefit and those within the dotted box might not have considered the marginal increase in net pay to be worth the effort of carrying out a job involving either shift work or weekend work together with a reduction in opportunities to carry out alternative tasks (i.e. moonlighting).

At this location records were kept of the date of birth, marital status and number of children of each person employed. I analysed these data although I realised that in many cases the information contained was not up-to-date. However, the average age for the industrial staff at this site was 40 years and the average age for the engineering staff was 38 years. From the records of dependant children the average number of children per married man was 1.96 for industrial staff and 1.97 for engineering staff. This fitted in very accurately with the similar statistical data from social trends which indicated that for a married man aged 40 in the United Kingdom the number of dependant children was 2. From social trends it was also possible to calculate that the likely ages of the two children for a man aged 40 would be 12 and 15 years. Thus, these ages were chosen for Table 15. Using the deduction for a married man with two children i.e. £19.50 and applying this to the net after tax pay of £53.96 (the average net pay for the staff) it is seen that such an average man at this location ended up with a net disposable income of £34.46 which was £5.09 below the supplementary benefit level. It was £13 below the 1.2 times supplementary benefit level which was considered to be the minimum level for persons employed and not necessarily those working unsocial hours. It should also be noted that for craftsmen and below, all married men with more than one child would be at, or below, the supplementary benefit levels. It should also be noted that the highest paid industrial staff (foreman grade 1 on shift) would be well below the supplementary benefit level if he was married with four children.

In a discussion with a senior staff member and the Department of Health and Social Security, I was told that the supplementary benefit levels could be (unofficially) taken as the base line for net living income below which the Government did not expect individuals to subsist. On the basis of data obtained it would seem as if a substantial number of power station staff were below these levels. The situation was exacerbated by the fact that virtually all the work involved either weekend or shift work which leads to a general expectation that financial rewards should be somewhat higher than those normal for five day week working. In a great many cases it was evident that income was supplemented by a working wife but this would restrict family daytime social activities to one weekend in four.

For the engineering staff, the rates of pay were compared with values for chartered engineers throughout the United Kingdom. The data for comparison was an engineer at Point 30 on a salary scale, equivalent to a second engineer rather more than half-way up the Band, and the total pay at the time of the analysis was £5,950 per year. The median salaries for fully qualified electrical and mechanical engineers were £5,900 and £6,200 per annum respectively in 1977. This near parity for power station engineers with the average rates for professional engineers is probably why there was little unfavourable comment about pay from engineers in this study. This is the more so if one considers that about 80% of the power station engineers would be classed as technician engineers and not as chartered engineers. Working a particular sample through as an exercise and assuming no shift allowance, the gross weekly pay would have been £114.42. After deducting superannuation, national insurance and tax (married man, 2 children) the net (take home) pay would have been £74.43. From this a deduction of £25 for mortgage and travel was made and a child allowance addition of £2.50 was made giving a net disposable income of £51.93. The average engineer's pay would therefore be outside the two supplementary benefit "boxes" and would be rather more than £6 a week above that of a foreman. However, it should be noted that a foreman would be working weekends whereas the engineer was on a five day week. Lower paid engineers (3E or EA) with family commitments could have found themselves inside the supplementary benefit "boxes".

Pay awards were made shortly after the completion of the study and during the writing up period. These awards amounted to an average of 19¼% for the four job examples chosen. In addition, a travel allowance became payable for industrial staff and the average value (equivalent to the average distance) was added to the examples. The supplementary benefits were also increased and comparisons were reworked. These indicated that the average man at the location would be about £3 a week better off than on supplementary benefit but still £4 below the 120% of supplementary benefit level. As can be seen from Table 16 the average power station industrial staff net increase of 14% was rather more than double the national average. It is also worth noting that the differential between foremen and craftsmen was increased and the differentials between labourers and craftsmen were decreased. Also, the differential for shift work was increased in relation to day work.

One or two other topics relating to pay arose at this location. Also, certain data were obtained about payments systems in overseas power stations. These items are presented in the following sub-sections.

Comments on overtime

During the study several people mentioned that trade union policy was to press for adequate manning at the location so that no overtime was required. In the event, this had generally been achieved on the operations side but a continuing shortfall existed in the maintenance branch. This was probably due to the greater opportunities for maintenance craftsmen to deploy their skills at other locations. It also resulted in the maintenance staff preferentially working overtime and the use of contractors on the site. Several of the foremen made the point that overtime should have been allocated to the operations and coaling staff. They suggested that the figure of 5% would have been appropriate i.e. equivalent to 2 hours a week. The foremen also considered that there was plenty of work that could have been usefully done on this plant to justify such levels. The operations staff were particularly aggrieved at the lack of overtime and the plant attendants

FAMILY STATE	FOREMAN 3 WEEKENDS IN 4			CRAFTSMAN 3 WEEKENDS IN 4			A.P.A. SHIFT			LABOURER 2 WEEKENDS IN 3		
	1977/78 Disp Income x 1.08	Cash Inc £ p	% Inc	1977/78 Disp Income x 1.08	Cash Inc £ p	% Inc	1977/78 Disp Income x 1.08	Cash Inc £ p	% Inc	1977/78 Disp Income x 1.08	Cash Inc £ p	% Inc
1	2	3	4	5	6	7	8	9	10	11	12	13
Single Man	45.78	6.93	15.14	40.27	3.63	9.01	36.80	4.84	13.15	30.62	3.68	12.02
Married, Child 3	45.37	7.78	17.39	39.86	5.70	13.20	36.39	5.80	19.94	30.21	4.64	15.36
" Children 12,15	48.69	7.99	16.41	43.18	4.68	10.84	39.70	6.90	17.38	33.52	4.74	14.14
" " 3, 9,11	51.26	8.14	15.88	45.75	4.83	10.56	42.27	6.06	14.34	36.09	4.90	13.58
" "8,11,14,16	54.79	8.22	15.00	49.27	4.92	9.99	45.80	6.13	13.38	39.63	4.97	12.54
Av. increase			15.96			10.72			15.64			13.53

National average increase = 14.2% - 8.0% (inflation) = 6.2% in real pay.

Av. for Power Station Staff (examples in table) = 14.0%

TABLE 16 INCREASES IN DISPOSAL INCOME BETWEEN 1977/78 AND 1978/79 recognized that unskilled staff could earn more than themselves. Another point made was that the first two hours overtime were paid at below the standard rate and this resulted in the men preferring to do a whole day's overtime rather than two hours. But it was recognized that two hour periods necessary to finish jobs were the most satisfying and the most valuable to the Board. Thus, it would seem as if the Board's overtime payment system penalized the most useful form of overtime. Quite a number of the maintenance men (working plenty of overtime) made the point that it should have been more evenly shared and several said they were not particularly interested in overtime and would much have preferred a standard working week with an adequate rate of pay.

The general feeling expressed was that it should not have been necessary to work overtime in order to achieve a living wage, but if such conditions existed then overtime should have been more generally available.

The location policy on overtime was constrained by the headquarters requirements of achieving not more than a certain percentage for the whole financial year. The monthly overtime figures vary from less than 1.5% to over 8% and the study of the records verified the operations staff claim that they work little or no overtime. A senior member of staff at the location pointed out that the financial benefits to the station were much greater for overtime worked by maintenance staff because of the high cost of contractors work.

Staff travel

Rather less than half the participants in the study commented on this topic and differing points of view were expressed. On the subject of travel allowances, a number said they did not believe in such payments and thought that the rate for the job should reflect the location of the station so that individuals could exercise judgement about the job in relation to its siting. Generally, those that lived nearer to the station felt some sympathy for those living 20 or 30 miles away and were inclined to favour some sort of allowance. Several mentioned the provision of station buses although most recognized the difficulty associated with such a scheme due the variety of destinations and work times. One suggested that a small bus should be provided to service the station approach road (nearly one mile long) so that the public transport could be used more conveniently. Nearly all the comments on the public transport condemned it for being far too slow and much more expensive then owning and operating a car. Examples of cost of public travel were given which seemed to substantiate this view. (£16p.w. was the cost for an individual living 23 miles from the station.) Quite a number said they could not afford to run a car and others said they would not incur the expense of one if they didn't need it for travel to work. Those living 20 or more miles away were able to do far less sharing than those living nearer. One also made the point that any travel allowances paid should be greater than the actual cost since they would be subject to income tax. However, none thought that the subsidy should equal the cost of travel. Thus the general concensus was that travel comprised a major expense for most of the staff and that some assistance with those costs should be given.

The largest item in travel costs are the fixed costs of keeping a car on the road. An unreliable car increases the risk of penalty through lateness and decreases the chances of sharing travel and so reducing costs. For the calculation of weekly costs, a car valued at £1,000 was assumed for the study. It was also assumed that a loan of £500 would be the average amount outstanding and would carry interest charges of £50 per annum. The calculation than was made as follows:-

	£
Cost of purchase of car (interest on loan of £500)	50
Annual depreciation	150
Tax and insurance	100
Tyres and maintenance	100
Total annual cost	£400
Average weekly costs	£8

For the running costs the following calculations were made and the figures shown relate to industrial staff and the figures following in brackets for the engineering staff. The average distance from work for industrial staff was 8.4 miles (10.5 for N.J.B.) therefore miles travelled per week equalled 84 (105). Cost of petrol and oil was estimated at £3 (£3.75).

The total cost of running a car equalled £11 (£12). Assuming sharing at approximately 2 per car the weekly cost would reduce to £10 (£11).

It should be noted that those travelling longer journeys (278 industrial staff lived further than 10 miles away) would have petrol costs of approaching £5 a week and a reduced opportunity to sharea car. However, the figure of £10 was taken for the pay calculations which would have been on the low side for engineering staff.

If the cost of car travel were calculated on the basis of the C.E.G.B. mileage allowance the calculations for one week would be as follows:-

¼ monthly allowance + 1/50th(tax + AA + minimum insurance) + 84 x the mileage allowance.

For class 2 users this would be as follows:-

$$\frac{22.5}{4} + \frac{50 + 10 + 100}{50} + 84 \times 8.589\text{p} = £16.04 \text{ (£17.84 for N.J.B.)}$$

If class 3 allowances (over 1600 cc.) had been used the £16.04 would be increased to £21.7 (£24.10 for N.J.B.)

Thus the £10 assumed was substantially less than the C.E.G.B. allowances. The study indicates that the costs of travel were considerable for the staff at this location. The new travel allowances were equivalent to £3.50 a week for someone living at an average distance from the power station. This was taxable and would be worth £2.30 net which would meet about ¼ of the cost of travel. Probably a fairer allowance would have been the difference between the average cost of travel to the power station minus the average cost of travel from residential areas to the typical local industries.

At Fossil Strand subsidized coaches were provided for the staff and were used by a reasonable number of day workers. At this particular site all the coaches travelled to the major nearby towns where a reasonable proportion of the total staff lived. No alternative to car travel existed for shift workers.

Information about overseas pay

Some information about pay rates was obtained in relation to the Detroit Edison plant but this referred to the visit in 1962. The pay rates were negotiated between the company and the unions representing the men. It was company policy to hire reliable men and to pay at higher levels than local industries. The company also provided incentives to encourage promotion for the staff and these included rewards for possessing more than one skill. Another important factor was the opportunity for staff to progress to comparatively high levels e.g. equivalent to shift charge engineer for industrial staff. A 5% premium was paid for afternoon shifts and 7½% premium for nightwork. Overtime was frequently offered and leave allowances were generous.

During my visits to some American power stations a certain amount of information was obtained relating to the pay scales. Within the T.V.A. the top jobs are related to the equivalent federal posts in much the same way as C.E.G.B. top posts are related to the civil service. Thus the Board of Directors within the T.V.A. received $40,000 (1976) whereas the equivalent post in smaller commercial power companies would range from $125,000 to $150,000 per annum. A new graduate engineer would have started at over $13,000 and risen gradually to approximately $27,000 after eight or more years experience. A series of management grades paralleled these engineering grades but rose to higher levels. The operations and maintenance superintendent would earn between $25,000 and $29,000 per annum. It was stated that a foreman working overtime could earn in excess of $22,000 a year i.e. equivalent to a graduate engineer with five years experience. Sick leave within the T.V.A. was on a progressive scale at the rate of 13 days for every year worked. After serving 40 years a man taking no sick leave would have earned the equivalent to two years additional service. On retirement he would be given the sick pay to which he would have been entitled. Thus, sick pay is of real value irrespective of whether an individual is sick or not. This system would not accord with the basic principle of the national health service but would be very effective in the real situation where it is generally recognized that much sickness absence is unrelated to physical incapacity. It was also pointed out that members of the T.V.A. can take retirement at any time between 55 and up to 65 years of age. The pension scheme is such that there is very little financial benefit in remaining at work after 62 years of age. In effect, most members of the staff opt to retire at around 60 years of age and those who have perhaps been less successful would probably leave sooner.

Overtime is part of the working pattern for staff in American power stations and can be worked by any member of staff to an overtime earnings limit of $10,000 per annum (assuming the need). From some payrolls produced during the visit,average values of overtime of around 16% were worked with much higher figures for the mechanical staff during an outage when their services were most needed. The reader is again reminded that the use of contractors would be exceedingly rare in any of the American power stations that I visited. In both the T.V.A. and the Duke Power Company, staff without university qualifications can progress without limit, but nowadays it would be usual for such progressions to stop at operations superintendent. Such progress would be less likely on the maintenance side. During outages a headquarters crew worked on the station and hired labour was engaged. This hired labour is attracted by the overtime rates paid and much of it would be classed as casual. Many craftsmen were members of unions and could earn at least average annual income by working 6-8 months a year on outages or other urgent projects where overtime was an essential part of the working pattern. In all such cases the power station staff were offered as much overtime as they wanted.

The visit of Buckley to power stations in the E. de F. in the late 1975 provided information on pay rates at that time. Within French power stations there was only one grading structure with a station manager at the top and unskilled staff at the lowest grades. Advancement could be obtained by the acquisition of additional qualifications or experience. Such advancement was a major factor in the motivation of employees. Professional engineers were all above grade 10. Each grade had a salary scale with a maximum of approximately 50% above the minimum. All the grades overlapped. At that time (1975) craftsmen were earning about £3,500; section heads approximately £7,000 and the station manager up to £14,000 per annum. In addition to these salaries all staff were paid a bonus related to E. de F.'s annual trading balance and generally equivalent to between one and two months salary. Shift work, overtime and holiday pay were all paid on a percentage basis as follows:-

Out of normal hours day work	10%;
Nightwork	30%;
Sundays	50%;
Daywork on a holiday	200%;
Nightwork on a holiday	225%;

Housing was provided by the Electricity Authority and the rent was deducted from pay together with security deductions. Income tax was paid directly by the employee and varied according to salary and family responsibilities. At an annual salary of about £13,700 the income tax payable by a man with two children was something over £3,000. It was pointed out that all salaries were paid by cheque monthly with no payments in cash. The writer of this report (Buckley) gained the impression after talking to a wide range of employees that they considered their pay, accommodation and working conditions to be good. Retirement with E. de F. is at 55 years of age as compared with 65 in general for France and the pension was to a maximum of 75% of the last year's gross salary per year.

Discussion of data

By comparison with its overseas counterparts, the C.E.G.B. comes out badly in terms of pay rates for industrial staff. The engineers appeared to be comparable with both the American and French power station engineers when allowance is made for the higher standards of living in both these countries. For the engineers, additional benefits are available in both the overseas countries in terms of early retirement and better pension facilities. The foremen within the C.E.G.B. (at the time of the survey) enjoyed some of the benefits associated with the engineering posts such as the superannuation scheme. It was also possible for the remainder of the industrial staff to pay superannuation contributions (it is now compulsory) but the net pay levels normally precluded such payments.

I attempted to obtain pay rates for other industries within the area but this proved very difficult. For those few obtained it would seem as though the power station rates were lower than other industries for commensurate work and these estimates are after the bonus has been included. The bonus was universally regarded by the staff as part of the pay and this view was normally taken by the majority of engineers and managers. Instances have occurred of bonus calculations being reworked to ensure the maximum was payable when the actual figures indicated a lower percentage. The statistics on net disposable income were disquieting since they indicated that very little financial benefit was to be gained by any of the industrial staff in coming to work. This was particularly so for family men with children and these were the very ones whom the unsocial hours had the most adverse effects. For a married man with a working wife on seven day rota, he could expect to have two days in the company of his wife in every twenty-eight not counting holidays. He would, however, have all the evenings together with his family. For the shift worker with a working wife, two full days in fourteen could be spent in her company together with a further five evenings in fourteen (on average). For these sorts of conditions most workers expect some compensatory financial rewards but the pay tables indicate that they actually suffered a net loss by coming to work. That this fact was accepted is indicated by the practice of having forms signed by the salaries section enabling many of the industrial staff at power stations to claim some supplementary benefits. Such claims make little or no allowance for car ownership which is the additional factor putting a majority of the industrial staff at the location studied below the supplementary benefit level.

Recently there has been an increasing awareness of this problem nationally together with some public pressure to reduce the numbers drawing supplementary benefits. In 1978, 41% of a group of 218,600 claimants went off the register after being interviewed to find out why they had not obtained employment. The question is also being asked nationally as to whether it may not be the case that a great number of people prefer to be unemployed and obtain supplementary benefit. This disquieting fact is that not only might they prefer it, they might even consider it their duty as the head of a household to remain unemployed. Under such circumstances it appeared to be the system at fault rather than individuals using it in a reasonable way.

The supplementary benefit commission in 1977 reported that 95% of unemployed claimants under 60 would have been better off in full-time work. These results are certainly not in accordance with my research findings and probably do not take into account car ownership or allow for high cost residential areas. To talk of shirkers is a bit hard if a man is going to be compelled to work (on shift or weekends) and end up with less money than he would have obtained on supplementary benefit. It behoves the supplementary benefit commission to rework its calculations and make recommendations for adjustments to the supplementary benefit rates or the tax cut-off points.

Another major piece of evidence to emerge in recent months has been the estimate of treasury officers of substantial amounts of undeclared income in the country (£11,000 million has been suggested). It is popularly supposed that shift workers have part time day jobs and this is probably true although few would admit it. One point to be considered is that a shift worker carrying out such a job might subsequently discover that he can quit his official job and draw supplementary benefit and then increase his part-time job and so obtain a far greater income with very much less effort.

It is also a thought that when men realize their labour is so little rewarded (or even unrewarded), unless they obtain some form of satisfaction from the job they would have very little incentive to continue it and very little compunction about taking a day off as sick when it suits them. The only obvious exception would be in the case of shift workers where the "esprit de corps" would cause a man to feel he had let his mates down by being late or taking a casual day's sick leave.

The earlier chapters in this thesis have indicated a general trend for C.E.G.B. power stations to be overmanned and as a result the Board might believe that its total wages bill is reasonable or it might take the view that if the staff wish to share the work they must be prepared to share the pay packet. But the earlier chapters also indicate that the main causes of overmanning are the inferior plant installed (compared with the U.S.A.) and the proliferation of systems. There was also some evidence of trade union pressure causing overmanning, especially at Ash Haven. A great deal of the attitude survey data supported the view that work output could be substantially increased thus enabling staff reductions to be obtained and better rates of pay offered.

Between the wars the industry paid above the average rates and the evidence suggests that the workforce was also above average. Company loyalty carried staff goodwill through a period when rates were below average but this is now being rapidly eroded judging by the comments in the attitude survey.

As a profit intensive industry, the C.E.G.B. needs to have an effective workforce which should be above average calibre and this is a policy apparently followed in the U.S.A. and E. de F. The policy should also be extended to working conditions and it should not be necessary for power station staff to have to work weekends or overtime in order to obtain a minimum living wage by supplementary benefits standards.

All the so called hygiene factors need to be reviewed in C.E.G.B. power stations and questions asked such as: Can shift and weekend work be reduced? Can staff and contractors be reduced to give more meaningful jobs to those remaining? Do we need such large numbers of highly paid N.J.B. staff to operate systems and perform technician work? Can we offer a grading structure with incentives for progression after the manner of that of Detroit Edison? The answers to many of these questions might beg the next question which is What about the surplus staff? Some thoughts on that topic are the subject of the next chapter.

CHAPTER 12

THE PROBLEM OF OVERMANNING

Introduction

A commonly recurring problem with research is the lack of measuring devices for making assessments. Currently, the C.E.G.B. is carrying out research into the manning levels in power stations for each of the five regions. On the basis of its findings, no doubt the region with the poorest returns will have pressure applied to improve standards. Such procedures have much in common with the laws of natural selection on the assumption that every now and again a variant will arise giving a more streamlined organization. A subsequent comparative study will then enable adjustments to be made to the other stations. Unfortunately, genetic mutations do not very often occur within a single family and such comparative studies need to embrace a sub-species. This research project has at least partially fulfilled that requirement and the sub-species might be considered as coal-fired, oil-fired or nuclear power stations.

Another difficulty with such "introverted" studies is that too many potential variables might be considered as fixtures. Thus the C.E.G.B. in its studies might take it for granted that the division between engineering and industrial staff was one such fixed parameter. Another danger of such investigations is to look at a group performing functions and use as a yardstick an optimum performance for such functions. Whether the function is necessary, whether its performance can lead to a negative productivity, are often matters not investigated. For example, many jobs performed in N.H.S. hospitals are often investigated and deductions made that they could be performed more efficiently. The question is not asked as to whether the American or Chinese hospitals perform similar functions at far less cost measured in terms of manpower. I chose the N.H.S. as an example because any dramatic improvements in efficiency could immediately be reflected in a desirable increase in total service to the benefit of the country as a whole. In the case of the C.E.G.B., improvements in manpower utilization would lead to a reduction in staff since there is no demand for increases in the electricity supply despite the efforts of some of its managers (e.g. Smith 1979) who said that the industry's (electricity) loss of ground as a heat supplier had to be reversed to ensure future growth and continued employment of staff.

As explained in the main part of the thesis, labour costs within the industry are smaller percentage of total costs (12%) and only about 5% of the total operating costs of a power station. However, what is important is the efficiency of labour, particularly in high merit stations, where the cost of lost load can easily be twenty times the total station labour cost.

In the chapter I shall first try and establish the full extent of the problem of overmanning in the C.E.G.B. and will then present some evidence as to its adverse effects. I will then generalize the discussion, since overmanning is only a problem if it exists in the national context. i.e. A company suffering from overmanning has no insurmountable problem if the country in which it operates is experiencing a shortage of labour. Some available statistics will then be used to try and reach some conclusions about ways in which the problem can be ameliorated. However, the main purpose of this chapter is to provide some data for use by others carrying out research on this topic and I do not pretend to be offering any solutions to a national problem.

<u>Power station manning levels</u>

The leaders of the supply industry in this country have generally maintained that serious overmanning does not exist. The Chairman of the Electricity Council in giving evidence to the Select Committee on nationalized industries (1978) said he did not think the manpower level in the industry would go down dramatically from the then current figure of 160,000. The Select Committee were critical and thought productivity did not compare well with electricity utilities elsewhere. They alleged that three American undertakings jointly employed 73,000 staff and served a similar sized population to the C.E.G.B. but sold one and a quarter times as much electricity. The Electricity Council Chairman said that American utilities purchase plant designed elsewhere and maintenance is often done by contractors. He also said that the Americans had a greater proportion of gas and oil-fired equipment than the C.E.G.B. The purpose of this research has been to fix some of the variables with the primary task of understanding how a power station organization functions. However, an important by-product of such research is the ability to make accurate comparisons of manpower making allowance for all those variables which are not fixed. Throughout this thesis, information about staff, how they work and what they achieve has been presented. It was apparent that the manpower requirements for coal-fired stations was substantially greater than that for oil-fired and it was also established that the manpower levels associated with the operation of any power station was not necessarily the total numbers appearing on the organizational chart. These "hidden" numbers mostly related to contractors staff at C.E.G.B. power stations and strangely, the power station practices in relation to the use of contractors was found to be the reverse of the situation presented by the Chairman of the Electricity Council. However, my data only refer to the T.V.A. and the Duke Power Company which were visited, together with some written evidence in relation to the power stations of the Detroit Edison Company.

The C.E.G.B. power station studied which had the tightest staffing levels (after making allowances for fuel type) was Downton and this was fortunate insofar as it was a station most nearly comparing to an American one. The American Marshall Steam Plant was also coal-fired, of four units, and 2000 MW. The differences were that Downton had four identical units of the same age and Marshall had two pairs of units of very different ages and of different size. The total manpower at Downton was 730 staff which included security, cleaning etc. The equivalent figure for Marshall plant was 180. The manpower equivalent of the revenue contracts for Downton was 50 staff giving a total of 780. The practice of carrying out centralized major maintenance at the American station increased the staff at Marshall plant by an average of 140 for a period of 5½ weeks which was roughly equivalent to 20 additional man-years of effort. Thus, the total manpower for Marshall plant could be taken as 200. If a very precise calculation were to be carried out then some allowance would have to be made for the fact that Downton had four identical units. With 780 staff equivalent, it would be reasonable to assume at least an additional 20 staff giving a conveniently rounded figure of 800 staff equivalent. Thus we find that when all the factors are taken into account the two most nearly identical stations have a difference in manning levels of four times. The "whys" and "wherefores" of these figures do not concern us in this chapter and have been discussed at length in previous chapters. Sufficient to say that the performance data relating to Marshall plant in terms of availability and efficiency is very much better than any figures for C.E.G.B. power stations. Therefore the result cannot be dismissed as due to ineffective operation.

If this discrepancy be regarded as some measure of the degree of overmanning within the C.E.G.B. and, therefore, some measure of the extent of the problem, then a list of all the major power stations within the C.E.G.B. together with their manpower figures and estimates of the American equivalents should enable the full extent of the problem to be assessed. The C.E.G.B. stations considered included only those with units of 100 MW or greater. (With the exception of three nuclear stations.) I considered that stations with units of less than 100 MW capacity would only be used for peak lopping in the future. The next problem to arise was the unavailability of data about C.E.G.B. manning levels with the exception of those for the South West Region. A request to London Headquarters for this information elicited the information that the manpower figures for each region's power stations was provided for London Headquarters use on the strict condition that the figures were not disclosed to any other person. The only figures available are average manning levels for all the power stations in the C.E.G.B. and these were as follows:-

250 MW - 1650 MW stations	380	total	staff	av.
stations greater than 1650 MW	748	"	"	"
nuclear stations	540	"	"	"

None of the figures above would include any allowance for the value of contract staff. An estimate for this purpose was obtained by assuming that one third of the value of all revenue contracts was attributable to labour and by further assuming that each £10,000 of the resultant sum was equivalent to one manyear. On this assumption the revenue contracts for the South Western Region power stations was converted into manyear equivalents (10 stations) and from these an average value for each class of station was obtained. This worked out at eighteen manyears for the nuclear stations which appeared to be rather low so a figure of twenty was taken. For the larger conventional stations ninety-five staff was the figure and for the smaller stations eighty-five staff. The resulting staff figures were as follows:-

Class B/C	250 MW - 1650 MW stations	465	total	staff	av.
Class D	Greater than 1650 MW	843	"	"	"
Class N	Nuclear stations	560	"	"	"

Table 17 is a list of all the C.E.G.B. power stations together with data about the size of units, year of commissioning and type of fuel used. Column 6 shows the class of station and column 7 the estimated total staff obtained as already described. Column 8, 9 and 10 are based on data relating to American power stations. Every two years statistical data about American power stations is published in the Electrical World which includes manning levels and average manpower levels for different classes of station. These have been used to provide the data in column 8. As already explained, many American companies carry out major maintenance using headquarters crews and the estimated number of crew weeks per year for each of the C.E.G.B. stations is shown in column 9. Taking average size crews, one crew week is equivalent to three manyears. This gives the total manyears

TABLE 17 CEGB POWER STATION MANNING LEVELS AND USA EQUIVAVALENT

STATION	UNITS	LAST SET YEAR	FUEL USED	MW TOTAL	CLASS OF STAT.	STAFF INCL. CONTR.	EQUIV USA STAFF	CREW. WEEKS /YEAR	TOTAL MAN YEARS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Aberthaw A	6 x 100	63	Coal	600	C	465	102	7	123
Aberthaw B	3 x 500	71	Coal	1500	D	843	150	5	165
Bankside	1 x 120	63	Oil	120	C	465	48	2	54
Berkeley	4 x 83	62	Mag.	330	N	560	100	5	115
Blyth A	4 x 120	60	Coal	480	C	465	82	5	97
Blyth B	2x330 + 2x260	66	Coal	1180	D	843	118	6	136
Bradwell	6 x 52	62	Mag.	310	N	560	93	7	114
Castle Don'ton	6 x 100	59	Coal	600	C	465	96	7	117
Cottham	4 x 500	70	Coal	2000	D	843	300	6	318
Didcot	4 x 500	75	Coal	2000	D	843	300	6	318
Drakelow B	4 x 120	60	Coal	480	C	465	154	5	169
Drakelow C	2x350+1x250	67	Coal	950	D	843	162	4	174
Drax	3 x 660	76	Coal	2000	D	843	300	6	318
Dungeness A	4 x 140	65	Mag.	560	N	560	90	5	105
Eggborough	4 x 500	69	Coal	2000	D	843	300	6	318
Fawley	4 x 500	71	Oil	2000	D	843	300	6	318
Ferrybridge B	3 x 100	59	Coal	300	C	465	96	4	108
Ferrybridge C	4 x 500	68	Coal	2000	D	843	300	6	318
Fiddlers Ferry	4 x 500	73	Coal	2000	D	843	30	6	318
High Marnham	5 x 200	62	Coal	1000	C	465	10	6	118
Hinkley Pt. A	6 x 94	65	Mag.	560	N	560	88	7	109
Ironbridge	2 x 500	70	Coal	1000	D	843	100	3	109
Kingsnorth	4 x 500	73	Coal	2000	D	843	300	6	318
Northfleet	6 x 120	62	Oil	720	C	465	115	7	136
Oldbury	2 x 313	68	Mag.	620	N	560	100	3	109
Padiham	2 x 120	62	Oil	240	C	465	72	3	81
Pembroke	4 x 500	72	Oil	2000	D	843	300	6	318
Ratcliffe	4 x 500	71	Coal	2000	D	843	300	6	318
Richborough	3 x 120	63	Oil	360	C	465	108	4	120
Rugeley A	5 x 120	62	Coal	600	C	465	102	6	120
Rugeley B	2 x 500	69	Coal	1000	D	843	100	3	109
Sizewell	2 x 325	66	Mag.	650	N	560	104	3	111
Skelton Grange	4 x 120	62	Coal	480	C	465	144	5	159
Staythorpe	3 x 120	61	Coal	360	C	465	108	4	120
Thorpe Marsh	2 x 500	66	Coal	1000	D	843	100	3	109
Tilbury	4 x 350	72	Coal	1400	D	843	140	6	158
Transfynydd	4 x 145	65	Mag.	580	N	560	93	5	108
Uskmouth	3 x 110	62	Coal	330	C	465	99	4	111
West Burton	4 x 500	68	Coal	2000	D	843	300	6	318
W. Thurrock A	2 x 200	63	Coal	400	C	465	128	3	137
W. Thurrock B	3 x 300	66	Coal	900	D	843	153	4	165
Willington A	4 x 104	59	Coal	400	C	465	128	5	143
Willington B	2 x 200	63	Coal	400	C	465	128	3	137
Wylfa	4 x 250	73	Mag.	1000	N	560	80	5	95
Grain	5 x 660	81	Oil	3300	D	843	495	8	519
Ince B	2 x 500	80	Oil	1000	D	843	100	3	109
Littlebrook D	3 x 660	81	Oil	2000	D	843	300	5	315
Hartlepool	2 x 660	81	AGR	1320	N	560	132	4	144
Heysham	2 x 660	81	AGR	1320	N	560	132	4	144
Dungeness B	2 x 660	80	AGR	1320	N	560	132	4	144
Hinkley Pt. B	2 x 660	78	AGR	1320	N	560	132	4	144
				54990		33171	8302	252	9058

1 Crew Week = 3 man years

PERO3ANJJOOP,2

figures in column 10. Not all American stations adopt headquarters maintenance and one in the current list(for example)which was a two unit station had 286 maintenance staff whereas the normal value for such a station in America would be 100. It should also be noted that the values taken for this particular study are the averages for the various classes and sizes of station in the U.S.A. and it will be seen from the table that the American equivalent value for a 2000 MW coal-fired station is 318 staff whereas I have previously demonstrated that the staff at the Marshall 2000 MW coal-fired plant in the United States was only 200 staff. In other words, the best of the American stations would provide manning levels very much better than those shown on this table.

As can be seen from the totals the C.E.G.B. staff is approximately four times the American equivalent staff. This is the same ratio as was found between Downton and Marshall, but as has already been explained, both Downton and Marshall had low staff figures by comparison with their national averages. Other factors to be considered are the existence within the C.E.G.B. of five regional headquarters plus a London headquarters, Generation, Construction & Design Groups and national laboratories. Of these, only the regional headquarters and the London headquarters should be compared with the Duke Power Company and T.V.A. headquarters, but once again the figures for the C.E.G.B. are not available. A conservative estimate for these six headquarters establishments would be 7,000 staff. The T.V.A. as a system is considered to be over half the size of the C.E.G.B. but with the plant in the planned or construction phase it will soon be about four-fifths of the size of the C.E.G.B. In addition to the headquarters staff which, I believe, was approximately 1,800 it has the centralized maintenance division, but these staff should not be included because they have already been allocated in this study to the power stations. There are probably other groups within the T.V.A. to handle the transmission network but it will be a very safe assumption that the total headquarters staff (excluding the contruction division) did not exceed 3,500.

Since the only object of this part of the exercise is to assess the extent of the C.E.G.B.'s overmanning problem, it would be reasonable to take a figure of 24,000 in relation to the power stations plus 3,500 for the headquarters staff. i.e. A total of 27,500 staff more than average American practice would use. This represents 69% of the total staff (inc. contractors) at present employed.

Some effects of overmanning

One effect of overmanning (although its very much a chicken and egg situation) is the proliferation of pseudo work. The best example of this in the C.E.G.B. power stations was the creation of work associated with the decision to extend formal work planning to the medium and short-term. The effects of the system have been discussed at lengths in earlier chapters but one or two quotations taken from interviews might serve to underline the effects on the staff. "Men often sign off jobs without them being done in order to keep the credits high".... "A large part of the work of the section (work study, 15 staff) is the routine timing on jobs etc."

Another problem arises from the inefficient way in which work is often carried out under the labour intensive work planning system. "When foremen planned work (on the spot) much more was done".... "Planners remote from job, the job cards don't relate".... "Easy for man to waste 1½ hrs., finding equipment, sorting out requirements and starting work". A detailed analysis of the work of one branch found that the men carrying out the work considered half their work was a waste of time.

Another effect of overmanning is the frequent waste of materials since unnecessary work is often associated with the use of unnecessary materials. Many examples were given of units of plant being dismantled new bearings etc. fitted because it was "due" under the planning system when it was known (not by the planners) that the plant had not been used since the last overhaul.

Another adverse effect of the loss of flexibility arising from long human work-chains was the inability to adjust priorities to suit plant requirements.

"Foremen use to ask for a "proper job" or maybe for a "quick job" and both types were different from the "official" time for the job .

Another failure arising from the effects of the system was the loss of "esprit-de-corps":-
"Men can leave jobs in a poor state because someone else will follow on"..... "More work done before P & P. Time taken was that required for the job. When job finished would help out other fitters."

Despite the systems,necessary work often did not get done because of the systems as the following quotes illustrate:-
"Decline of the 'A' station mainly due to P & P; now not able to use discretion, judgement or take pride in work.".... "Often extra work needed on plant but this is not reported, system too complicated and not worth the fuss".

With all its complications, work planning (and many other support systems) failed to achieve the desired results (more efficient plant) because of the identification with organizational targets (e.g. achievement of desired number of credits):-
"Before P & P the foreman organized work and maintained work pressure" .... "Job cards filled in to suit the system".... "Alot of nonsense written on them".

Perhaps one final criticism is that such systems seek to substitute the "stick and carrot" approach in place of an attempt to provide genuine work interest:-
"Doesn't like stick and carrot system - be good boy and get your bonus".

Probably the greatest tragedy of such systems was that before their advent many power stations were efficiently run and offered their staff job interest, a sense of achievement, and a pride in their work. The system was presumably introduced to deal with those stations which failed to achieve such objectives but was also imposed on the effective stations.

In the Regional headquarters, whose primary function is to provide support services to power stations, there has recently been a drive to make some small reduction in the total staff numbers in order to comply with Government policy. One or two younger individuals leaving under the scheme have been asked to keep the fact secret from their colleagues since the management fear a precedent may be caused and have an incipient mass exodus on their hands. (They could be well advised to let it rip, but it would raise some very awkward questions).

The national problem

At this time (1980) many organizations are attempting to reduce staff in order to become more competitive. Egs. are British Steel and B.L. Cars. Some interesting figures for the car industry were given in a paper by Lee (1980) which showed that work was carried out for only 41% of the actual nominal working time. Similar studies have been carried out in other industries and it is often alleged that low productivity exists in such organizations as British Rail; British Airways; National Health Service hospitals.

This type of overmanning which relates directly to such practices as work measurement doesn't usually take into account the need for certain functions. An example of this form of overmanning was given when Weinstock's G.E.C. absorbed A.E.I. and E.E. Two substantial headquarters organizations were virtually disbanded and their effective output absorbed by the smaller G.E.C. headquarters.

It is not the purpose of this study to examine the efficiency of various industries or even to ask whether overmanning is a pecularly British phenomenon (evidence suggest it is not). However, it is generally considered that overmanning does exist (an opinion shared by some members of Government) and it is claimed that overmanning contributes to our poor economic performance. It is suggested that Government departments (national and local) tend to indulge in 'system and rule thinking' which results in a degree of overmanning in these organizations. Changes are affecting other labour groups for example the retailing industry is experiencing a large reduction in staff as a result of larger retail centres being created. A recent survey of the U.K. clothing industry (C.I.P.R.A. 1980) found 58 support staff for each 100 production workers. The German figure was 29.

Extent and effect of the problem

In the power stations with which this research is concerned, the potential reduction in labour is well over half. The manning level reductions in electrical distribution during the last war indicated that there is probably scope for reductions in that part of the industry also. Reports from other industries and the imminent prospect of the automating and computer controlling of much of industry would make an approximation of a 50% reduction in the national workforce a reasonable estimate during the next decade or so. The present workforce is about 26 million and something approaching 2 million will be unemployed by the end of 1980. The implications of the figure of 50% excess staff (out of the total labour force) is that there are perhaps 11 million under-employed staff in the present workforce of 24 million. It is arguable that much of the current industrial unrest stems from the high unemployment levels. If these did not exist then many staff dissatisfied with pay or working conditions could more easily change their jobs. Also, the unions are probably more concerned with the unemployment problem than with low pay. Further, the effect in world economy terms of U.K. productivity at 50% can only mean a shared pay packet to match the shared job.

Shorter working weeks and longer holidays are no answer to the problem since most workers want a reasonable standard of living and halving the working week and doubling the workforce would have a precisely zero effect on pay and productivity levels. The only permanent solution is a reduction in the size of the workforce. Many staff interviewed (usually aged over 60) said they would retire if they could.

PART 4

THE INDUSTRY

A look into the technical and political history. The forces that shaped the U.K. and U.S. industries and the effects on the organization of power stations.

CHAPTER 13

TECHNICAL HISTORY

Introduction

In this part of the thesis I shall attempt to relate findings from the study of power stations to events and influences arising during the industry's evolution. Some of these events were indirectly linked to the industry but I shall confine myself to those influences having a direct contact. This would be the second layer, an enclosing outer shell, if one were considering a model with the power stations at the centre. The main influences were the technical history, the political background and the structures of the parent organizations. The technical history was shared by all countries but the political influences differed and those in the United States are considered separately and some comparisons made with the U.K.

Shortly after writing the next four chapters a new book was published (Hannah 1979) on the development of the electricity supply industry in Britain until nationalization in 1948. The book was sponsored by the Electricity Council and is intended to be first of three volumes providing an authoritative history of the industry and the impact of technical innovation on modern economic life. From the information provided in the book it is apparent that subsequent research has placed rather a different emphasis on certain topics and this has necessitated some amendment in the first two chapters.

Early Inventions

Before Faraday's discovery of electro-magnetic induction in 1831, a considerable amount of work had been done which probably started with Guericke who, in 1671, built an electrical machine comprising a sulphur globe which was charged by rotation with a cloth held against it. Early in the eighteenth century, the connection between electrical charges and electrical current was discovered and the Leyden jar demonstrated the ability to make and transmit electricity over long distances. In 1790 Volta developed a battery and expounded a theory of current electricity.

In the years following Faraday's discovery, a number of experiments made use of the principle to convert electrical into mechanical energy using batteries. However, the costliness of batteries limited the applications until self excitation was discovered in 1867, together with the ring wound armature in 1871 by Gramme. These advances brought the dynamo to the point where it could be used to generate electricity at a practical level.

Another important technical advance was the invention by Jablochkoff in 1876 of a practical form of the arc lamp which had been first demonstrated by Humphrey Davey in 1808. This device, in conjunction with the Gramme dynamo, enabled a start to be made in the wider use of electricity. The "first power stations" were engine houses (often wooden sheds) with semi-portable steam engines driving Gramme dynamos (generators) and their separate field excitation dynamos. These began to appear in France in 1877 and in this country in 1878. It should be remembered that traction engines were in their hey day and it was simply a question of coupling a dynamo instead of e.g. a threshing machine to the drive belt.

The next importance advance was the incandescent carbon filament lamp demonstrated by Joseph Swan in 1878 and patented by Edison in 1879. These lamps made the internal lighting of buildings a practicality and started an increasing demand for a supply which was initially met by the provision of equipment for individual premises.

The first installations

The first installation to offer a public supply was at Godalming in 1881, followed by a more successful one at Holborn in 1882. Other public supplies were established in England during the same year and one in New York in late 1882. In the following years these numerous installations with their station engineers gave rise to a great deal of practical development and problem solving making the systems more reliable and viable. One very important series of technical developments was associated with the Grosvenor Gallery Station in New Bond Street. This was established in 1883 in an outbuilding and quickly expanded to supply the neighbourhood. In 1885 a larger station was built in a new basement to serve this system and Ferranti was engaged to solve the technical problems associated with it.

Its subsequent success led to an appreciation of the size of demand for lighting and Ferranti had the vision to plan the first large central power station. This was to be sited at Deptford with the intention of supplying alternating current to the whole of London by the use of high voltage cables and local transformers at substations. The scale of the enterprise was vastly greater than anything previously attempted and the power station was a building 200 ft sq. x 100 ft. high and twelve units were planned, each of 10,000 H.P. generating at 10,000 volts. The boilers were to operate at 200 p.s.i. which was also far in advance of anything previously attempted. Construction was under the direction of Ferranti and involved some new technical achievements such as the machining of castings 11 ft. in diameter x 25 ft. long.

The cables for transmitting the supply from Deptford to the West End were unsatisfactory and Ferranti had to invent and develop methods of manufacturing cables and jointing techniques for transmission at 10,000 volts. These were the fore-runners of modern cables. Some of the Ferranti original cables lasted for forty years in service. The Deptford project suffered delays mainly due to the cable problems. At the same time the demand had increased (probably deliberately encouraged in expectation of the new supply) and the existing Grosvenor Gallery Power Station burnt out due to overloading before Deptford was operational. By this time the system covered most of central London and during the enforced three months closure most of the customers were lost to the many small rival D.C. suppliers. This caused financial difficulties and spelt the end of the early hopes of providing a single supply of A.C. electricity for the whole of London.

This disaster in 1890, due to the overloaded system and the panic action of one operator, probably had a considerable influence on the future of the electricity industry because the success of a high voltage long distance alternating current system would have reduced much of the subsequent direct current development with its multiplicity of small power stations. Another factor supporting the proliferation of small stations was the development of the very efficient and reliable Willans engine and by 1892 these provided the motive power for over two-thirds of all the dynamos in use. Also, legislation tended to support the existence of a large number of small stations, but this will be discussed in the next chapter.

Abroad, such efficient high speed direct coupled engines (the Willans engines) were not commonly used and much larger, slow speed units coupled to dynamos by belts were installed. This practice favoured larger power stations because of the increased efficiency related to size. Some such machines were installed in this country.

However, this stage rapidly came to an end with the development by Parsons in 1884 of steam turbines which were the final major contribution to power station technology as we know it today (nuclear energy apart). The first Parson's turbo-generators to be installed in power stations were at Newcastle in 1890, although a substantial number were already in service before that date as lighting generators on ships.

Growing Up

Initially, the rate of installation of turbines was slow, but their flexibility and reliability came to be recognized and they were increasingly favoured. Manufacturing rights were acquired in the U.S.A. in 1896 and in Europe in 1900. As they became larger and technically more advanced their efficiency soon exceeded that of the reciprocating engines and their supremacy was then unassailable. By about 1910 they were established as the only prime movers for power station work and, technical improvements aside, subsequent development has been confined to increasing the size and raising the operating conditions. In 1900, two 1 megawatt single phase units were installed by Parsons (plus a small three phase unit) and in 1912 the same company installed a 25 megawatt unit in Chicago. In 1922 a 40 megawatt unit was installed at Barking and a 105 megawatt unit at Battersea in 1935. By this time, rather larger units had been installed in the U.S.A. The initiative for technical improvements probably passed to the U.S.A. during the 1930's (e.g. hydrogen cooling). Increased thermal efficiency by a larger size and higher operating conditions was the main motivation for the larger units. This led to a 1,000 megawatt cross compound unit being installed in New York in 1965 and a 600 megawatt single shaft unit in France in 1968. A 1,100 megawatt unit was built in 1969 in the U.K. for installation in U.S.A. and the largest units at present in use are of 1,300 megawatts, the first being commissioned in 1972.

Progress in distribution has depended more on policy decisions than technical innovation. The technical stages started with the work of Ferranti in developing and operating twenty-eight miles of 10,000 volt wax impregnated paper insulated cables in 1889. In 1891 electricity was transmited 110 miles at 25,000 volts in Germany. Development of cables progressed steadily and 132kV single core oil-filled cable was used in 1926 in the U.S.A. Air blast circuit breakers were invented in the U.K. in 1926. A 220kV single core cable was used in France in 1936 and 132kV three core cable was used first in U.K. in 1943. In 1965 a 226 mile transmission line at 735kV was commissioned in Canada and 400kV cable was used in the U.K.

The nuclear phase

The remaining technical aspects of the industry relate to the advent of nuclear power and its history is briefly as follows. In 1919 Rutherford at Cambridge succeeded in splitting atom using alpha-particles and 1932 Cockcroft, Wallace and Chadwick working in this country split atoms by bombarding them with protons and nutrons. Subsequent stages of the work were primarily directed towards atomic weapons, but in 1942 the first nuclear reactor was built in the U.S.A. The first major nuclear power station was opened in 1956 at Calder Hall, but its primary purpose was the production of plutonium for military use and electricity was a by-product.

In 1960 and 1961 two nuclear power stations whose primary function was the generation of electricity, were commissioned in the U.S.A. In 1962 Britain's first nuclear power stations for the production of electricity were opened at Berkeley and Bradwell. The main trend of U S.A. nuclear power has been to use water cooled and moderated reactors (P W.R. and B.W.R.), whereas in the U.K. graphite moderated and gas cooled have been the type commercially developed. The first nuclear programme use the magnox type and the proto-type advanced gas cooled reactor (A.G.R.) went into operation in 1962. The first commercial A.G.R. was Hinkley Point 'B', commissioned in 1977. The next generation of nuclear fission reactors in the U.K. are likely to be the P.W.R. followed in the 1990's by the fast breeder reactors (F.B.R.) which produced fissionable plutonium from non-fissile uranium 238. In the F.B.R. technology the U.K. achieved a substantial world lead with the prototype going into operation in 1962. However, the early promise of commercial use by 1980 has not been realised owing to technical, economic and political factors including environmental concern. The ultimate energy future probably lies with nuclear fusion which avoids most of the radio-activity hazards and enjoys an unlimited raw materials source.

Summary

This brief survey of technical aspects of the Electricity Supply Industry leads one to the general conclusion that this country has been well to the fore in technical innovation having made a fair contribution to the internationally shared developments in the industry. Because of this sharing, the organizational structures of the national electricity supply industries ought to have developed along broadly similar lines. But I believe the combination of legislation and technical misfortune played a very significant role in the U.K. development. The D.C. suppliers who were inevitably small because they relied on batteries, received a double boost with the Grosvenor Galleries/Deptford failure plus the advent of small reliable Willans engines. This made it all the more difficult for subsequent A.C. suppliers to expand, grow and use new technology. Therefore, I think the Grosvenor Galleries fire was a point of inflection and set the U.K. industry back by 20/30 years. I shall review these developments both in the U.K. and U.S.A. in the next two chapters.

CHAPTER 14

DEVELOPMENT OF THE INDUSTRY IN THE U.K.

Introduction

In this chapter I shall look briefly at the influences and forces, other than technology, which shaped the U.K. electricity supply industry. These influences were held to have retarded the economy as a whole by many people as will be apparent from some of the published statements. This was particularly so at the turn of the century.

Much of the information for the earlier part of this chapter was derived from books from Parsons (1936); Self and Watson (1952); Dunnsheath (1962). Also, published reports by the Electricity Council (1973) provided a valuable framework. For the second part of the chapter (post nationalization) the main source of information has been Government published papers.

It is my intention to deal with the information briefly but certain aspects which I consider to be relevant to the present situation in the industry will be analysed in greater depth.

Earlier Legislation Influencing the New Industry

The early 19th century saw the rise of the belief that open competition would safeguard the public against exploitation. Municipal corporations had been reformed with the Act passed in 1835 and 1836 but they were still not regarded as aspirants for municipal trading. However, the trend was for change and allegations of mis-management by some of the gas undertakings led to the Metropolitan Gas Company Act of 1860. Following this, many municipal gas undertakings were created. The Tramways Act of 1870 provided for the public management of another group of utilities and the urban horse-drawn tramways were constructed. The Public Health Act of 1875 authorized municipalities to undertake ownership of yet another utility, namely, the waterworks. The urban general public were beginning to become familiar with technology as by this time the railways, gas lighting, telegraphy, piped water supplies and sewage schemes were all in operation.

The 1882 Act

Progress with a new electric lighting was slow and generally only the wealthy could afford the new system. For the vast majority, paraffin or candle-light was commonly used or gas lighting in urban areas. The gas mantle, invented in 1886, became popular a few years later and provided incandescent lighting which was much steadier than old "fish tail" gas lights. Municipal control of the gas companies and Government legislation prevented excessive profits and resulted in them providing an efficient and economic service. This enabled them to take a much larger share of Britain's need for lighting and effectively pre-empted the market for electricity. The much more rural U.S.A. had a less well developed gas industry and this fact presented much greater opportunity for the development of the emergent electricity industry. Byatt (1962) calculated that in 1890 gas had 68% of the U.S.A. lighting market and nearly 100% of the U.K. By 1899 gas held 41% in the U.S.A. and 92% in the U.K.

Public interest was aroused by the arc lighting installations on the Embankment, Holborn and Billingsgate in 1878 and in the same year thirty-four private bills were introduced seeking the legal right to give a supply to various areas, including the right to break up streets for mains (c.f. the gas undertakings). A Government select committee (Playfair) was appointed in 1879 and recommended that the right to lay street mains should rest with local authorities as a public safeguard in exchange for the granting of an electricity supply monopoly. The committee also recommended that such monopolies of supply to private companies should only be given for a limited time after which the local authority have the right of purchase. This was a similar condition to that in the Tramways Act of 1870. The Electric Lighting Act of 1882 gave recognition to the industry and incorporated most of the recommendations of Playfair. Local authorities could provide a supply or consent to a private supply. They were also empowered to purchase private undertakings after twenty-one years without any compensation for good will etc. The Act prohibited the association of separate undertakings. The Act also gave the public the right to demand a supply of electricity. The restrictive clauses caused damage to the industry by limiting growth through amalgamation and by discouraging investment. But it must be remembered that long distance transmission was not then regarded as practicable or necessary. The continuation of this attitude was the real loss to progress arising from Ferranti's Deptford failure.

The Act was claimed to have paralysed the industry, but this was an exaggeration. The real problem was the speculative risk involved with many local authorities already owning the local gas undertaking and not being willing to see it usurped. Three years after the Act no licences had been proceeded with and progress was mostly made by companies who could circumvent the Act by avoiding the need to break up streets. Overhead lines were used (with local authority consent) and sometimes cables could be laid on private property, e.g. the Deptford scheme used railway tracks. During this period a great many small companies were formed, but gradual extension of systems led to applications for wider franchises and for these the need for longer periods of tenure were evident.

Establishment of the Industry

Despite the pressure in Parliament, it was 1888 before a new Electric Lighting Act extended compulsory purchase laws from 21 to 42 years and also laid down that purchase should be at "a fair market value". This gave an immediate impetus to the industry, for example; registered share capital in 1885 was £58,000 and in 1889 it was £4 million. Many questions were left unanswered by the 1888 Act, such as the situation arising under the compulsory purchase powers when an undertaking served more than one municipal area. A Board of Trade Inquiry under Major Marindin gave some important guidance which resolved some of these problems. It defined conditions and imposed certain standards on all undertakings. The right of individuals to a supply was emphasised and direct competition was encouraged, although only two licences would be granted for any one area.

During the following years power companies (as distinct from light companies) emerged and twenty-one acquired rights by private Bills. These covered the entire country, excluding municipalities. There were a number of pressures causing this change. One was the desire to use electricity for traction. By 1897, 90% of U.S.A. tramways were electrified and the ultimate inevitability of this system for the U.K. tramways was accepted. It was delayed because the Tramways Act of 1870 had provided for compulsory municipal takeover of the private companies after twenty-one years and as a result the companies were naturally unwilling to invest in electrification with little chance of financial gain. As they were subsequently taken over they were electrified and by 1905, 90% of the U.K. tramways had been converted. During this period the London Underground was largely developed and totally electrified as were many suburban railway systems. This led to a seventeen fold increase in the use of electricity over a ten year period (Byatt 1962).

Considerable social changes arose from the urban transport revolution and electric power became accepted both by the public and by industry. Many progressive firms installed electric motors for driving machinery and found they made substantial operational savings over the existing steam powered mechanical drives. They also discovered that electricity had a greater range of uses than steam powered drives. These diverse uses for electricity inevitably led to better load factors, but not immediately. At first the electricity generating facilities were separate; electric lighting companies provided light with load factors of around 10%; tramway power stations had load factors of about 20% with rush hour peaks; factory generating plant had load factors also of around 20% but at a different time of the day. It was realised that central generating facilities and amalgamation of various uses would have much improved load factors.

Coalescing into an Industry

The engineer who most successfully promoted these amalgamations was Mertz who was appointed Consultant Engineer for the Newcastle Electric Supply Company in 1899. In the following years he, together with associates (McLellan) built up the most successful electricity undertaking in the U.K. Carville power station was pioneering in terms of efficiency and economy. At a later station costs were even more dramatically reduced and progress in unit size was rapid. The growth of the company and its accompanying load factor (45% in 1908) gave it advantages which enabled costs to be reduced and which, in turn, further increased its growth. It ultimately became the biggest integrated network in Europe.

This bright spot in the U.K. electrical development was seldom matched elsewhere and complacency, municipal jealousies and the political dogma of free enterprise all conspired to defeat attempts to emulate the Newcastle undertaking. Mertz himself, with many financial backers, attempted to promote a similar massive scheme for the London area which would have revolutionized industrial production. It was defeated by the pressure of opponents. Some of the problems raised by this situation were dealt with in the 1909 Electric Lighting Act which gave undertakings certain powers such as the acquisition of land by compulsory purchase.

The next Act was in 1919 and in the intervening period a great deal of progress took place, but the earlier legislation still restricted amalgamation. It also encouraged competition and this led to the biggest battle which was between A.C. and D.C. systems. In 1894 there were 320,000 A.C. lamps and 373,000 D.C. lamps in the London area. Over the rest of the country there were 181,000 lamps on A.C. and 235,000 on D.C. At that time D.C. was still more economical for the small stations that existed because demand could be smoothed by the use of batteries which also provided cover for breakdowns. During the same period the reliability of plant was improving and large units were appearing which clearly pointed the way to high voltage A.C. supplies as being the system for the future. By this time the D.C. systems were firmly entrenched and the results of this situation had far reaching effects. For example, in 1921 London had 80 different supply authorities operating a total of 70 power stations. They used 50 different systems at 24 voltages and 10 frequencies. As late as 1966 there were still 20 areas of the country with D.C. supplies. Such was the outcome of the dogma of free enterprise.

The 1914/1918 War period led to a doubling of demand with the need to ensure that the most efficient use was made of the new generating plant (45% increase). Compulsory co-operation towards integrations and the taking of bulk supplies promoted considerable unification of existing small undertakings and some reduction in the variations of systems in use. Lloyd George appointed McLellan to supervise the additions and the Newcastle strategy was followed with larger sets being used (one of 25 M.W.). Where possible, additions were designed into an overall national scheme. Several reconstruction studies were made. A committee was set up by the Board of Trade and chaired by Parsons (in 1916). The report produced summarized the situation and stressed that the local and political handicaps had crippled the electricity industry in which Britain had been pre-eminent and our international lead and competitiveness had been lost. They further said that British industry in general would be severely handicapped unless we considered electricity generation and distribution on a national scale. The estimated savings were put at not less than £1000 million per year. A separate sub-committee dealing with coal usage (Haldane 1916) made similar recommendations for the control of electricity generation. One final committee was set up (Williamson 1917) and it recommended the nationalization of electricity generation and main transmission. It suggested a series of integrated districts each under an electricity commissioner who would have very full powers. The committee also recognized the savings in reserve capacity arising from such inter-linking and considered that the country's prosperity depended on extensive electification of industry including the railways.

Yet another committee (Birchenough in 1918) was asked to consider the main conclusions of the Williamson Committee. Its report went one stage further with a recommendation that a single unified generation and transmission system should be created which should be State controlled and financed. It should also be run on commercial and not civil service lines with the Electricity Board absolutely free to consider and deal with the whole problem of electrical supply. This recommendation anticipated the 1947 Nationalization Act by 28 years but was opposed by the existing industry who supported the creation of a Board of Electricity Commissioners having advisory powers only. The 1919 Bill was introduced giving the Board compulsory powers but the Electricity Supply Act which was finally passed created a Board of Commissioners with advisory powers only. The main beneficial effect of this Act was the removal of restricted legislation which had previously limited co-operation between undertakings. The Government tried again in 1920 to give the Commissioners compulsory powers, but again the Bill had to be withdrawn. Another attempt was made to encourage re-organization in the 1922 Bill, but the main groups affected aligned themselves for self-protection behind Conservative Balfour who strongly supported private enterprise and limited legislation. His own company (Balfour Beatty) subsequently became the largest electricity private holding company.

The recognition of the need for an industry operating on a bigger scale was universal and political pressure for reform continued. The 1924 Labour government found the idea of state intervention more acceptable and an inquiry into the coal and power industries was carried out with Lloyd George as chairman. The Committee once again considered that national prosperity depended on the greater use of electrical power and proposed that the Electricity Commissioners should be given compulsory powers. It was also proposed that they should construct a transmission system. These proposals were elaborated by a Mr Twiss who proposed that the transmission network be owned and operated by a national body empowered to purchase and sell electricity in bulk. The Government set up a Committee (Wier 1925) who recommended the creation of a Transmission Board who would construct a "grid" and operated by purchasing in bulk all electricity generated and selling it at cost price to the distributor undertakings. Although there was much opposition, the Bill was substantially passed as proposed in the form of the Electricity Supply Act of 1926.

Unification

The Central Electricity Board (C.E.B.) was established in 1927 to operate on a business footing. It was protected from undue state interference by its terms of reference. When connected to the grid, stations continued to be operated by the owners, but the Board took over responsibility for all costs and directed operations. Some control by the state was possible through the Electricity Commissioners who still carried out such functions as approving schemes to be carried out by the C.E.B. and who arbitrated in any disputes between the C.E.B. and existing owners. Within a year the C.E.B. had produced an overall scheme and had adopted national standards for supply (3 phase, 50 cycle and 132kV). The country was divided into nine areas (subsequently reduced to six) and within five years the initial grid was complete with about 4,000 miles of primary and secondary transmission lines. The Board had also established control centres in each of the areas with a national control centre subsequently being established in 1938. The savings and economies affected by operation of the grid were estimated at 17% of production costs and a greatly reduced generation capacity being required to meet the total national electricity load. Before the grid, the average level of spare capacity was 40%, but after some years of successful operation spare capacity levels of 10% were found to be possible. It was estimated that savings of £22 million on spare plant had been made by 1937. The grid also allowed greater flexibility on the siting of industry and new generating plant. One unexpected benefit was the ability to absorb the spare capacity of hydro-electric schemes in remote areas. This resulted in much of the U.K.'s hydro-electric plant being installed at that time.

The grid also gave an impetus to the use of larger units of plant and the "merit order" purchasing methods of the Board ensured a ready market for the output of such plant. However, the benefits of standardization were also considerable, resulting in 30 M.W. and 50 M.W. units being favoured with exceptional items of sizes up to 105 M.W. occasionally being installed (e.g. Battersea). During this period British electrical equipment manufacturers began to prosper and formed successful protective trade rings which the Board's power was unable to break (Hannah 1979). Nevertheless, plant prices came down with increasing unit size. The clause put in the 1926 Act at the insistence of Balfour(enabling electricity producers to buy bulk supplies at a price no more than it would have cost those producers to generate their own) led to many disputes and cost the Board a great deal of money. But it did finally strengthen the case for the Board ownership of power stations. The industrial load increased greatly in the early years, but many large industrialists with continuous processes found it cheaper to generate their own electricity, being able to obtain a better load factor and make use of the process steam. As a result, more than half the industrial load was generated privately in 1935 (Hannah). Domestic consumption increased rapidly with the number of houses provided with electric lighting rising from about one million in 1926 to eight million (two-thirds of the total) in 1938. By this time nearly three-quarters of the domestic load was for uses other than lighting, but this load was mainly confined to middle-class homes. It should be noted that as early as 1935 the possible adverse effects of direct domestic heating load on the peak system demand was noted and advertising for such loads was dropped.

The success of the C.E.B. led to continuing pressure for rationalization of distribution systems. Better use of capital investment (about half went on distribution) would arise from using natural distribution areas, rather than artificial ones, such as local authority boundaries. Cost of electricity depended more on the effectiveness of organizations than on their size (a result of grid distribution) with the average cost per unit from the suppliers of 80% of the total load being 2d.(old pence) The average cost for the remainder was about 2.7d. (1935). Medium sized and municipal (often synonymous) undertakings were the cheapest on average and tended to provide better customer relations.

But major economies were still possible by mergers and particularly from standardization of voltages etc. Also of concern were the high dividends being paid by some of the private companies and the fear of monopolistic holding companies (American style) getting a grip on the industry (see next chapter). Thus, a general recognition of the need for rationalization was frustrated by forces of civic pride, self interest and conflict between the principle of national ownership and private enterprize.

The first nationalization proposals by Morrison in 1931 were lost when the Government lost office. Recommendations for compulsory mergers were made again in 1936 but were defeated by municipal interests. Preparations for war took priority over any further plans for re-organization and, apart from a lull at the beginning, the industry's capacity was extended by the war-time demands. Extensions to plant had to be minimized and loads greatly increased. The load centres also shifted, requiring some additions to the grid and new stations in the west of the country. War damage to plant was relatively slight and the system load factor increased from 36% to 50%. Output nearly doubled during the war with a major constraint being the shortages of plant and coal. The problems of fuel rationing gave raise to the creation in 1942 of the Ministry of Fuel and Power which largely took over the role of the Electricity Commissioners and became responsible for authorizing new plant. The plant authorized for 1947/48 was well below the estimated requirements and the existing plant at the end of the war was in poor condition. In 1946 sales of consumer goods and particularly of electric fires (several millions were sold in 1946) together with immersion heaters put the industry in an impossible situation. With less than 300 M.W. of additional generating plant commissioned and with about a quarter of its plant nearly fifty years old, the severe weather of early 1947, excerbated by continuing shortages of coal plus frozen coal stocks, gave rise to extensive power cuts and major industrial disruption. This resulted in a priority for the ordering of new stations with a Ministry of Supply carrying out an investigation of the electrical manufacturers and finding inefficiency and disorder which largely arose from the distribution undertakings continuing to do their own ordering to their own standards. The Ministry imposed standardization of many items including generating sets (30 and 60 M.W.s).

Although the adverse effects of the heating load on peak demand were clearly recognized, the domestic tariffs made the use of electric fires far more economic than the burning of coal in open grates. This was recognized, but the industry were still thinking along the pre-war lines of continuing growth and competition with other fuels.

During the war the Government considered the needs of the industry and it was generally agreed that the distribution side needed re-organization. The North of Scotland Hydro Board was created in 1943. Most agreed that the C.E.B. should take over full responsibility for generation and the C.E.B. Chairman proposed that thirteen distribution boards be formed, each reporting to the minister with the C.E.B. responsible for generation. After the Election, the Labour Government nationalized the industry, creating fourteen area boards under the direction of the British Electricity Authority (B.E.A.) which had direct responsibility for generation and transmission and reported to the Minister.

Post Nationalization Changes

The Electricity Act of 1947 created the B.E.A. plus 14 Area Boards by taking over the 537 undertakings and extinguishing the C.E.B. and the Electricity Commissioners. The B.E.A. was divided into 14 divisions, each one coinciding with an Area Board. The divisions (and the Area Boards) had considerable autonomy and created different structures. Overal co-ordination of generation and distribution rested with the B.E.A. as did responsibility for the whole of capital expenditure.

Staff negotiations in the new structure were based on the councils which already existed and provided for the various groups of staff. The National Joint Industrial Council (N.J.I.C.) which had been created in 1919 continued to act for industrial staff. A similar body the National Joint Board of Employers and Members of Staff (N.J.B.) had also been created in 1919. Clerical staff were to be covered by the new National Joint Council (N.J.C.) to provide a similar negotiating function with the new authority. In 1951 the National Joint Managerial and Higher Executive Grades (N.J.M.) was formed. The purpose of these negotiating bodies was seen as providing a system of communications so that management intention and plans could be discussed and staff feedback obtained. At this time the idea of such communications with staff within large organizations was considered to be innovative.

In 1954 the Government, perhaps not entirely satisfied with the performance of the industry, established the Herbert Committee to carry out an inquiry and to make recommendations. Also in 1954 the two Scottish Area Boards together with the generation and transmission facilities were amalgamated as the South of Scotland Electricity Board (S.S.E.B.). This change left twelve area boards and the B.E.A. became the Central Electricity Authority (C.E.A.) serving England and Wales.

The Herbert Committee found that the industry had been successfully unified under the B.E.A. (now C.E.A.) and the need was for more delegation of authority. They considered it would be difficult for the C.E.A. to be impartial in their judgement when they generated the electricity and supervised both the generation and distribution. They believed the need was for a separate generating function plus an overall co-ordinating body. The Electricity Act of 1957 carried out these recommendations with one important exception and the present structure of the industry was thus established. Briefly, this is as follows:-

a. The Electricity Council (E.C.) comprising six members appointed by the Minister plus three from the C.E.G.B. and the twelve Area Board Chairmen. Its functions are mainly to advise the other boards and to perform some common services such as national pay negotiations and co-ordination of capital programmes.

b. The Central Electricity Generating Board (C.E.G.B.) comprising up to ten members appointed by the Minister. Its function was to generate and transmit electricity.

c. Twelve Area Boards each with up to eight members appointed by the Minister. Their principle function, of course, was to distribute electricity.

The main criticism of the new organization from within the industry was the lack of authority vested in the Electricity Council. The Herbert Committee had recommended such powers, but the Minister saw fit to withhold them.

In addition to the main recommendations, the Herbert Committee made well over 100 points in comments, including recommendations for changes, both in the way the generating and distribution functions were carried out. Some of these recommendations were quite detailed, for example, they said station superintendents should continue to be responsible directly to divisional controllers. Some of the main critical comments made by the Herbert Committee which might be relevant to this study are as follows:-

a. They criticised the time taken to construct power stations and the duplication of design effort by headquarters and divisions.

b. That operational research and work study should be used for greater efficiency and manpower deployed more effectively.

c. Incentive payment schemes should be introduced.

d. Better utilization of both capital and manpower resources should be made.

e. Capital should be raised by Boards in the open market.

f. Sales of off-peak electricity should be promoted.

g. The Boards should buy plant in the cheapest market without regard to national interest.

h. More research and development should be done and greater use made of science.

j. Work on nuclear power stations should be increased.

From the above selection of points it is evident that the Herbert Committee was very critical of the existing situation within the C.E.A. and Area Boards. Thus, it would seem as if the statistical evidence of the improvements made since nationalization did not over impress the committee. As a result, they wanted to delegate responsibility downwards to individual boards and to create the central board (Electricity Council) which to quote their words - "should seek to create for itself a reputation of being at once judicious and stimulating and should see its main duties as keeping the industry on its toes and critically reviewing the Board's policies, programmes and expenditures". The Electricity Council was set up but it was not given such powers.

This was the last committee whose recommendations led to actual changes in the organizational structure although some of the Plowden Committee's recommendations were due to be implemented, but the Bill was defeated in Parliament. However, many select committees and other official bodies have looked at the industry in the intervening years and some of their findings are examined in the next section.

<u>Some investigations and pressures on the C.E.G.B.</u>

The Herbert Committee was the first of many similar Parliamentary bodies appointed to investigate the industry or the C.E.G.B. Its recommendations not only led to the creation of the C.E.G.B., but determined many of its initial features. Generally, such investigations are by Select Committees of the House of Commons. These are appointed by the members to carry out inquiries on their behalf. Ownership of a nationalized industry is vested in the Members of Parliament who thus have the right to require those industry's leaders to give accounts of their actions to the committee. Ministers, as appointed agents of the members, are also required to account for their actions before Select Committees.

The C.E.G.B. came into existence in January 1958 with a number of clearly defined guidelines arising from the criticisms made by the Herbert Committee. It met those requirements by creating five regions within the first year to replace the old divisions and by transferring responsibility for the design and construction of power stations to three project groups. Research activity was also stepped up substantially with the creation of several new centres. On the question of nuclear power the Government White Paper (the Nuclear Power Programme) was produced in 1960 proposing a programme of one power station per year until 1968. Members of the C.E.G.B. also produced a paper (the Economics of Nuclear Power) in 1960. They concluded that it should be comparable in cost with coal plant by 1965/70.

The Nugent Committee investigated the industry in 1963 following the severe power cuts in the 1961/62 winter. Their main criticism was the failure of the planning system within the industry to anticipate future growth and the actions of the Area Boards in promoting domestic load by under-pricing electricity and making the task of meeting peak load requirements even more difficult. They also recommended increasing reserve capacity to 25%.

The C.E.G.B. put forward the view that being the largest single integrated electricity system in the world, the reserve capacity could be lower than that of other countries. (In practice, the integrated networks of the U.S.A. and Europe are both greater than the C.E.G.B. and this would probably be the main determining factor for a reserve capacity.) The need was also recognized for an increase in load factor with the figures for the other countries being significantly better than that of the U.K. The recommended solution was the building up of an off-peak domestic heating load. Nevertheless, the overall commercial ethic was to increase total load and to catch up on generating capacity by overcoming the bottlenecks. The worst of these were the poor industrial relations in the construction industry. Another major problem was the monopoly buyer position of the C.E.G.B. with the result that the manufacturing industry also behaved like a monopoly by creating price-rings. It was suggested that the industry's productivity was comparable with other countries, but effective comparisons could not be made due to different working practices.

The preparation of a National Plan involved the supply industry in forward commitments in common with other U.K. enterprises. The industry stated that during the five years it would increase spare capacity to 17%. Thermal efficiency would increase from below 28% to 33½%. The industry undertook to double its generating capacity, to increase electricity sales by two-thirds, but to use only 17% more manpower (there was a shortage of manpower at the time). It was stated that computer control, work study, operational research and automation would lead to lower staff levels, but the biggest factor would be the installation of larger generating units. One concern of the industry was doubts about manufacturers ability to meet the delivery dates for new equipment.

A Government White Paper on Fuel Policy acknowledged that the electricity industry had been directed to use oil instead of coal in the earlier years and subsequently to switch back to coal by taxing oil. Government thinking was that adequate oil supplies existed for at least 35 years, plus oil shales equal to seven times the known reserves of oil. It was estimated that in 1964 about 15% of the primary fuel used in the country was converted into electricity and then back into heat. This half of the electricity output was in competition with other forms of heat, but the other half (lighting, motors, etc.) was a monopoly market.

In 1966 and 1967 two further papers were produced and during this period North Sea Gas was emerging as a viable fuel. It was suggested that gas could take a larger share of the heating load (30% of all energy in the U.S.A.; 6% in the U.K.). The capital cost of gas installations was only 20% of the comparable electricity generating costs. The Select Committee in 1967 criticised the time taken to build U.K. power stations by comparison with those in other countries. The C.E.G.B. said more staff, both technical and labour, were deployed on site in Japan and U.S.A. and there were fewer labour disputes. It was also said that there were fewer technical changes on new plant installations in those countries. The site management in the U.K. was allegedly very poor. The C.E.G.B. admitted that plant installations were even further behind schedule, but expected to have caught up by 1967. Off-peak heating loads were going to be developed and these were considered necessary to make the distribution network viable. The Chairman admitted that electric fires were the main peak load problems. Comparative costings were given which indicated little difference between oil and coal fired modern plant, but potential savings when using A.G.R. nuclear reactors. The Chairman anticipated that "battle" with the gas industry for the domestic heating load.

In a series of investigations covering the process industries the National Board for Prices and Incomes (N.B.P.I.) agree to allow pay increases in return for increased productivity. There was general recognition that overtime had become a fairly universal device for increasing pay and had given rise to a distortion in working practices and the loss of control of work output by the industry's management. Probably the most famous of these schemes were the Fawley Agreements which reduced average hours from 56 to 42 per week by a major re-organization of working practices and substantial increases in basic pay. The main aim of the C.E.G.B. in its agreement was to introduce a standard seven day working week in place of Monday to Friday with overtime at weekends. Such working patterns were considered to be necessary for continuous operation of process industries. A condition of such schemes by the N.B.P.I. was that payments should only be made if productivity increases resulted. The

Electricity Industry Scheme which became effective in 1963 was far less specific than the two Esso Agreements and included in its aims the "best possible use of manpower" and "practices to improve efficiency".

A subsequent review in 1967 concluded that the benefits to the Board had been the seven day working practice and the elimination of overtime. However, the average earnings of the manual workers had only risen by 12%, which compared badly with the 17% for industry in general. There had also been a 10% rise in the number of manual staff employed. However, the drop in take home pay was almost entirely due to the lack of overtime since the hourly rate was slightly above the national average. The unions were now pressing for an increase to bring earnings in line with the national averages. In evidence, the S.S.E.B. claimed that the use of work study and working standards had given productivity increases of 10% with a reduction of 8% in manpower and a further 8% reduction expected in the following year. As a result, the N.B.P.I. recommended that the Electricity Council adopt productivity schemes on behalf of the industry. They also recommended the establishment of a data bank of work study standards and that the improved productivity should be a joint responsibility shared by management and the unions.

After a year the N.B.P.I. were asked to review the results of a year's operation and to consider the proposal for the pay and productivity scheme devised by the Electricity Council. This scheme proposed a bonus of one third basic salary for a performance of 100. The N.B.P.I. described the scheme as an incentive scheme, rather than a productivity scheme, since its purpose was to pay the maximum bonus for working at the expected standard. The minimum performance was taken as 65, which the N.B.P.I. considered to be too low, but they thought the current performance of the industry was certainly below 65. The N.B.P.I. saw the scheme as being a useful facility for getting productivity in the industry back to the correct levels and recommended the scheme be ended and normal payments made when performance was back at the correct 100 level. The N.B.P.I. also thought that considerable reductions in manpower would be required and that a voluntary early retirement scheme should be considered, especially as the industry was running into surplus capacity conditions. They also suggested that the scheme, and the work standards, should be monitored by an outside group such as themselves. The C.E.G.B. considered that such schemes were not generally applicable to generation and would be essentially unsound. The N.B.P.I. calculations estimated reductions in manpower of up to one third if the scheme was properly operated.

In 1969 the N.B.P.I. reviewed gas prices and some interesting facts emerged. It was evident that the inherent storage capacity of the gas distribution mains enabled the industry to meet peak demands far more readily than the electricity industry. The figures indicated the probability that the gas industry would ultimately pick up the peak heating load at present carried by the electricity industry and by so doing lead to a surplus of electricity generating capacity. It was also interesting to note that the Gas Board's incentive scheme paid for performances up to 167%.

A Government White Paper on Fuel Policy was produced in 1967 proposing the maximum use of North Sea Gas and the recognition that domestic heating load would be the largest single use. Domestic appliances were to be converted on a ten year plan. Future growth of the electricity industry was expected to be lower than previously forecast. The A.G.R. programme was recommended mainly as an alternative to the use of coal. One reason for these proposals was to limit the dependence of the country on overseas oil imports which were currently providing 37% of the total energy requirements.

The N.B.P.I., in a submission to a Select Committee, suggested that their function in relation to the nationalized industries was to substitute some of the market pressures which would exist for the rest of industry. It was recognized that pricing policies could not be separated from the Government policies. It was also recognized that the real issue was the means of controlling monolpoly power and the suggestion was made that the only solution lay in the reduction of such power. The nature of monopolies was such that inefficient ones could make profits, whereas efficient ones could be loaded with constraint and make losses. It was also recognized that many pressures existed for central control, such as the need for wage negotiations and purchasing requirements. The statement was made that a U.S.A. utility selling 25% more electricity than the C.E.G.B. and serving a similar number of people employ a total of 73,000 staff, whereas the C.E.G.B. had 160,000. The Electricity Council Chairman said that no U.S.A. utility carries out its own maintenance and they use more gas and oil for which maintenance requirements are lower. He also said the intention was to equal the U.S.A. productivity.

In 1970 a Select Committee investigated the generating plant breakdowns associated with the 500 and 660 megawatt units. It was pointed out by the C.E.G.B. that the units were ordered eight years ago when there was no experience with this type of plant and delays in commissioning meant that type faults were built into a number of units. It was also stated that most of the failures were due to design incompetence and not due to technical advances. Boiler problems were associated with the poor workmanship on site and poor industrial relations were blamed for some of the malicious damage. The large number of designs and manufacturers were now reduced to two (for turbines) and the C.E.G.B. were going to buy abroad in the event of any future failures of design. The committee suggested that the C.E.G.B. enforced penalty clauses more strictly in future.

Capital investment was investigated by a Committee in 1973. Pricing Policy had been overriden by the Ministry in order to serve the national interest and the committee believed that this had led to a lowering of morale within the industry. They recommended the establishment of a Committee of Inquiry who were not members of the Government or in Government service. The Electricity Council submitted that the reserve plant margin was now 20% and the new plant planning was for six years ahead. They also said that corporate planning and economic assessments were carried out which included risk and regret analyses. The 1965 National Plan requirements had apparently been quietly dropped by 1967 and the industry now made its own decisions about future movements in the economy, but based on Government information. A major constraint for the industry was its statutory duty to provide electricity on demand. In most corporate planning the available resources are deployed for the best future use, but the statutory duty, coupled to the Government control of tariff, meant that electricity had been sold too cheaply, demand encouraged and future investment in additional plant would be inevitable. The Electricity Council Chairman did not think that the structure of the industry was ideal. He confirmed that fast breeder reactors were the long term thinking at present. The committee were critical of the 500 and 660 megawatt sets and also the policy of building large power stations. The C.E.G.B. confirmed that large orders were placed on the basis of the 4% per annum growth required by the National Plan. Of the forty- seven units, thirty-six were running in 1973. He said that using smaller units would mean that present electricity prices would be 25% greater.

In 1975 a committee on energy conservation was set up and it recommended that ways of using electricity generation waste heat should be found, probably by de-centralization of generation into smaller units. It was acknowledged by the central policy review staff that the C.E.G.B. wished to increase the use of electricity and the Government wished to reduce the total use of energy. It was also stated that there was 45% excess generating capacity in the country.

The Plowden Committee submitted its report in 1976 and this summarized their recommendations and findings relating to the re-organization of the industry. They pointed out that an attempt had been made in 1970 to give the Electricity Council control over the other electricity boards. Sales and generating capacity had increased 2½ times since 1958 and domestic consumption had increased 150%. They noted that substantial staff reductions had been made (over one third of industrial staff) following the introduction of the productivity schemes and the use of larger units. However, the reduction in non-industrial staff was only about 6%. They found that loyalty to individual boards often took precedence over loyalty to the industry due to lack of central direction. Council members primarily represented their boards and decisions were often compromises. The C.E.G.B. tended to be a law unto itself and yet 79% of area board costs are C.E.G.B. electricity. The committee tried to assess the efficiency of the C.E.G.B. in relation to other country's industries and the only figures they could arrive at were overall thermal efficiencies. On this account the C.E.G.B. was the worst of the eight countries considered. Also noted was the C.E.G.B.'s continuous commissioning backlog (11 years) and still (then) running at 6,500 megawatts. The Committee were critical of the C.E.G.B.'s earlier planning involving orders for 47 sets in three years. Thirteen boiler and turbine designs were involved and the whole programme was totally beyond the capability of the industry, or the C.E.G.B. to control. Load factors were slowly improving, but were still below 50% for these units. The committee recommended that the industry should assess its own efficiency more effectively. They suggested that the industry should consider other means of generating electricity and make more use of heat and electricity schemes. This could mean giving generating capacity to the area boards.

The functions which were identified as being national in nature were the grid control, power station design, load forecasting, fuel policy, tariffs, financial policies and industrial relations. Unification with central direction was recommended with authority being devolved as much as possible. The suggestion that the Electricity Council should be retained with power to direct the boards on strategic matters was rejected because of divided responsibilities and accountability. This would maximize managerial freedom at board level instead of at district level. The committee could see no advantage in the creation of power boards, and preferred central overall decision making. They considered that power boards with surplus generating capacity would be in too strong a bargaining position vis-a-vis those without. Other advantages of central control were the smoothing of equipment ordering.

They recommended that the board members should not have line responsibility, but a generation and distribution central department should be created. They proposed that more than half the board members should be part-time and from outside the industry. These would provide a constructive criticism of the work of the full-time members. They considered that the consultative machinery was fine in theory, but was considered to be cumbersome by the members of the organization. They therefore recommended simplification. Worker representation on the Board was proposed but to be built up from within the staff rather than via the unions. They also recommended that the Government should not use prices and capital investment as regulators of the industry and such practices in the past had done considerable damage. They proposed that the consultative councils representing consumers should be given more power to prevent the abuse of monopoly power by the industry. A National Consultative Council was recommended whose chairman would be a member of the main board.

In a submission to the 1978 Select Committee on Nationalized Industries the Electricity Council Chairman maintained that the productivity improvements had been dramatic in the last ten years, with the labour force going down from 220,000 to 160,000 at the same time as output went up. He could foresee no similar further reductions of such magnitude. The committee were critical and thought the industry did not compare well with productivity in other utilities elsewhere. However, the Chairman said comparisons were difficult, for example, American utilities buy plant design and have contractors for maintenance, whereas the C.E.G.B. design and maintain their own plant. The Chairman also stated that the staff required for a 2,000 megawatt station was similar to that for a 600 megawatt station ten years previously. He considered that capital investment had accounted for 10% of the productivity change. He also suggested that American utilities use a much greater proportion of gas and oil than does the U.K. Coal fired plant is much more maintenance intensive. The Chairman considered that two-thirds of electricity generation would be nuclear by the year 2000. In the meantime, a substantial percentage of the generation would be by coal with oil remaining relatively unchanged. It was pointed out that the delivered cost of natural gas was 1.9p per therm, whereas the cost of coal and oil for the C.E.G.B.

was 8.4p per therm. Thus, he thought that gas was being sold too cheaply. The Chairman also considered that there was now a general acceptance that nuclear power was necessary.

In evidence submitted to the 1978 Select Committee on nationalized industries the trade union representatives suggested that the industry would run itself better without ministerial interference. They also stated that union representation on the industry's board would not be desirable as this would put them on both sides of the negotiating fence. They considered that industrial democracy was intended to make the life of the man at work more meaningful. They welcomed the new Joint Co-ordinating Council and thought it might be extended to the working units i.e. power stations. It was also considered that the old consultative machinery needed improvement and was not of much interest to the workforce. The primary interest of the workforce was the working environment and the wages and it was management's task to involve people more in their work. Thus a change in management's approach to the workforce was needed. The union representatives favoured internal appointments to subsidiary boards. Members of the consumers council expressed a preference for power boards because they considered the C.E.G.B. to be remote from the needs of consumers.

Representatives of the electrical manufacturing industries thought the electrical industry should be operated as a commercial enterprise and not be involved in social considerations. They favoured a central body for strategic matters and were totally opposed to the clause allowing the industry to manufacture or sell electrical plant or fittings. They did not favour power boards since these would lead to a fragmentation of planning. Criticisms were expressed of the C.E.G.B.'s planning failures which were leading to a starvation of orders and could lead to the elimination of the boiler manufacturers in this country.

The Minister in his submissions said that he did not think power boards were the right solution for the industry. Ministerial appointments gave a man far more autonomy and freedom in his opinion than did internal promotions. Thus, he considered that the gas industry was far too centralized whereas the electricity industry at present was far too de-centralized. Nationalized industries should always be fully accountable to the Minister and should not be allowed to manage themselves absolutely. He agreed that perhaps some of the power of a Minister should be devolved to Parliament.

The Committee finally concluded that a re-structuring was necessary and that uncertainty was bad for the morale of the industry. They expressed a preference for the pre-legislative hearings of such proposals. The view was expressed that the industry should be more accountable to Parliament and they suggested that the Select Committees would be an appropriate medium for such accountability. Such committees would also be suitable for the confirmation of appointments of Chairmen of nationalized industries.

Summary

The industry grew very rapidly at the start with many major technical developments originating in this country. The initial need was to encourage private enterprise to ensure rapid growth and experimentation. The legislation of 1882, together with the supremacy of gas, discouraged such enterprise. The Act of 1888 ameliorated the worst effects and the industry was becoming established. The Deptford venture which nearly succeeded clearly pointed the way ahead in terms of size and scale of operation. Political leadership lagged and it was not until 1926 that effective legislation enabled it to expand into a national service. By this time the fragmentation of the industry arising from earlier legislation was so great that the mess was still being cleared up by nationalization in 1947. The initial "grid" was installed rapidly by the C.E.B. who gained a reputation for efficiency otherwise the history of the 1939/45 war might well have been different.

During the whole of this period from the beginning of the century onwards unfavourable comparisons of our productivity were being made and they frequently referred to the total usage of electrical power per work in industry. Wier in 1925 stated that the U.S.A. used twice as much electricity per worker as the U.K. Thus there is some evidence that the slowing down of our industrial progress as a nation during this forty years might have been avoided by more effective legislation. The initial industrial revolution created on the use of steam gave the country an impetus in the eighteenth century which carried it well into the nineteenth. The same inventiveness was re-applied in the early development of electricity and this could have enabled the country to retain, or regain, its pre-eminence into the twentieth century. Some idea of the damage caused by poor legislation can be gained by some of the figures available for the growth of consumption after the creation of the C.E.B. In 1926 consumption was 7,000 million units at a cost of 1.65d per unit. By 1947, and with an industry greatly restricted by lack of generating capacity, consumption had increased by six times and the cost per unit had dropped to 1.08d per unit. During the period the price of coal had increased 2½ times. In the U.S.A. the comparable figures were 80,000 million units in 1926 which increased by four times by 1946.

The success of the C.E.B. probably highlighted the deficiencies of the distribution system and the need for larger units with more rational boundaries than official town limits. Also, distribution networks accounted for half the total investment capital and were therefore a significant factor in overall costs. Recognition of these factors led to general acceptance of the need for re-organization. Also the success of the C.E.B. and an awareness of the abuses of monopoly power under the American holding company system (see next chapter) led to the nationalization of the industry by the Labour Government.

Initially the C.E.G.B. set itself up in accordance with the requirements of the Herbert Committee and was grouped into regions. However, the area boards had not been set up in accordance with the same requirements and were free from restraint by the Electricity Council, the controlling body. Their individualism enhanced their competitive commercialism and a desire for growth. Since nationalization, this equating of commercial growth with efficiency has bedevilled the industry. It led to the need for a massive increase in generating capacity and the refusal to recognize the inability of the country's available resources to meet such an expansion. During the war similar desires had been severely restricted by the Ministry of Supply. Probably the greatest single factor affecting the industry was the inefficiency of the manufacturers of the plant (alleged by the C.E.G.B. Chairman) and the subsequent pressures and problems this failure posed for the C.E.G.B.

Trade union pressure was generally for comparability of wages with those in outside industry and this pressure was supported by the N.B.P.I. The N.B.P.I. found the industry to be inefficient (in common with many other industries) and the proposed cure was to link wage increases to productivity increases.

The main outside pressures on the C.E.G.B. were the advent of North Sea Gas and the quadrupling of oil prices at a time when the C.E.G.B. had its maximum commitment to future oil-fired plant. The oil price increase caused the Government to manipulate the economy by artificial holding of the cost of electricity and this led to a subsequent increase in demand.

These were some of the main constraints imposed on the C.E.G.B. but there were other more general constraints such as the nationally prevailing low levels of productivity and certain legislative measures such as the Health and Safety at Work Act. It should be noted that the industry was not subject to many financial restraints except some retardation in the middle of the 1960's.

CHAPTER 15

HISTORY OF U.S.A. INDUSTRY AND U.K. COMPARISONS

Introduction

The information relating to the American supply industry has primarily been obtained from two sources, namely, "Electric Power and Government Policy" (1942), a major research report published by the 20th Century Fund which is a charitable trust sponsoring important investigations. The other source of information is the "National Power Survey" produced by the Federal Power Commission in 1964 and again in 1970.

Growth and Structure of the Industry

The supply industry in the U.S.A. started in 1880 when a New York Electric Power Company installed a water driven generator for arc lights. A much more significant beginning was the installation in 1882 by Edison of steam electric plant to light 10,000 lamps. In the U.S.A. the demand for lighting was far less well satisfied by the gas industry than in the U.K. leaving the way open for the electricity companies. As the proliferating small companies extended their systems they encountered competition from others. The disadvantages of such competition were clearly apparent and combinations and consolidation took place giving rise to the typical situation of local monopolies by the turn of the 19th century. Regulation by municipal franchise and sometimes by state utility commissions was employed to protect the public against wasteful competition and excessive tariffs, whilst at the same time providing investors with some safeguards.

Since its inception, the industry has expanded at twice the rate of the overall economy and is now the largest industry in the country. Until 1900 the only prime movers available to the industry were the slow

Corliss steam engines with ratings up to 2,500 H.P. The invention of the Parsons steam turbine overcame the prime mover bottleneck and enabled the capacity of single units to increase. This was followed by increases in boiler size which, coupled to increased reliability, have led to the present universal adoption of single unit boiler/turbine/generator combinations. The growth in size of units has always provided a spread of sizes in commission, but the typical maximum size of units in use was 75 M.W. in 1930; 100 M.W. in 1940; and 175 M.W. in 1950. Immediately following the Second World War the demand for power and the need for improvements in technology led to a departure from the previous practice of advancing into larger sizes and higher steam conditions only after adequate knowledge and experience had been obtained following the previous advance. Thus, new and larger units were ordered before the lessons had been learned from the previous equipment. The largest units immediately after the war were about 150 M.W. but by 1964, 1,000 M.W. units were being built and 1,300 M.W. units in 1970.

The initial power stations provided electricity over very limited distances being constrained in the same way as those in the U.K., but the advent of the transformer enabled larger distribution networks to be employed. Advances in technology and growth in load further increased the opportunities for integration of generation and transmission. This system of integration progressed and by 1964, 97% of the industry's capacity was inter-connected into one of five large networks. The largest inter-connected group of systems in 1964 comprised 167,000 M.W. covering most of the eastern half of the United States plus some of Canada.

The industry in 1964 comprised 3,600 separate systems, of which 3,200 were small. The largest group were the 480 investor owned systems providing over three-quarters of the generating capacity. The next group, the Federally owned systems provided 13% of generating capacity from only 44 systems. Over 2,000 publicly owned systems accounted for 10% of generating capacity and the Co-operatives owned less than 1%. The 100 largest systems accounted for 90% of total generation and

2,000 systems were only engaged in distribution. Over 900 of the systems had small loads and generating capacity to match and, therefore, could not benefit from economies of large scale generating units. Most of the United States networks have now been inter-connected and additional substantial east-west links are planned. The inter-connections enable north to south power transfers to be made on a seasonal basis and east to west transfers on a time of day basis.

In 1964 it was predicted that electricity would provide 30% of energy requirements by 1980 but by 1970 this prediction had been reduced somewhat and it was becoming recognized that growth of future demand could not go on indefinitely. Alternative strategies are now being planned to hold the forward momentum before the 1990's. Future hopes are placed on nuclear breeder reactors and ultimately on the use of nuclear fusion power. The larger investor owned groups continue to absorb the smaller private or municipal undertakings and closer co-operation has enabled better use to be made of spare plant. There is also a growing awareness that the United States uses 40% of the world's total electrical energy with a population comprising only 6% of the world's total.

In the United States forward planning of plant requirements is generally confined to five years ahead with the exception of the purchase of suitable sites which is on a fifteen year basis. The nuclear programme suffered significant delays as a result of which the spare capacity has dropped from approximately 25% in 1963 to around 15% in 1980. Over the years the trend of electricity prices has been continuously downward but this has now stopped and the future forecasts are for continuing upward trends.

Holding Companies

Amalgamation of the small investor owned systems mainly came about by the emergence of holding companies in the 1920's. Most of these holding companies were created to cover contiguous areas, but some were financial empires comprising unrelated systems and effectively blocking power system integration. By 1929, seven holding companies controlled 60% of the total industry and a Government Act was introduced in 1935 which ended many of the more serious abuses by limiting a holding company to a single inter-connected system serving contiguous territory.

Common practice of the electricity machinery manufacturers was to help small utilities finance their equipment purchases. Holding companies were created which issued bonds and shares against operating company stocks. Other holding companies were formed to surmount State legal barriers which prevented utilities from being operated by "foreign" corporations. In these cases the holding company often provided centralized managerial, construction and operating services for those companies whose shares they held.

The electricity operating companies on average obtain two-thirds of their capital by bond and preferred stock issues and only one-third by the common stocks which possessed all the voting power. Thus, control of these electricity companies by the holding companies could be obtained with about 16% of the total capitalization. These holding companies in turn were pyramided in exactly the same way by other holding companies which, therefore, required an ever smaller proportion of the original common stocks to exercise control of the operating companies. Out of thirteen large holding companies controlling substantial electrical systems, five of them controlled their systems with common stocks whose nominal value was less than 1% of the systems total assets. It needs to be realized that bonds and preferred stock are entitled to fixed returns and once these have been met all additional profits accrue to the common stockholders. In one or two notable cases there were pyramids of nine holding companies separating the operating units from the small group of individuals who wielded the power. Such systems were wide open to abuse and led to Government participation in the industry.

Legislation

The U.S. Government recognized that technological and economic conditions made local monopolies the most favoured type of organization for the industry. The Government was also aware that monopolies are under no pressure to charge prices which cover competitive costs plus reasonable profits. Also, it was known that certain types of consumer could exert more pressure on the utilities than others causing "unfair" tariff differentials. Initially, price regulation was local, but this was too rigid, inept and very often corrupt. As a result, two states in 1907 established administrative commissions with power over electrical utilities. A majority of the other states subsequently followed. However, private power systems expanded beyond the state line and outside the jurisdiction of the state authorities. Many of the financial practices of the systems were censored and industry was charged with avoiding a state regulation. As a result, the Federal Power Commission was given authority in 1935 to regulate inter-state wholesale rates for electricity.

The intentions of the Federal and state governments were often frustrated by the Supreme Court's right to determine fair rates of return for undertakings. For example, in 1923 the Supreme Court ruled that public utilities were entitled to returns on investments equivalent to those of other business undertakings with corresponding risks and uncertainities. Such rulings were wide open to various interpretations and stemmed from that part of the Constitution which forbids the taking of private property without due process of law. The famous interpretation of this was in 1898 in the Smyth verse Ames case. It could be paraphrased as follows:- "the Company ..... is entitled to ..... a fair return ...... On the other hand ..... the public is entitled to demand ..... that no more be exacted .... than the services ..... are reasonably worth". This case was the bedrock for much of the history of the American power system and was not seriously overturned until 1938 when the Supreme Court upheld the Federal Power Commission's right to prescribe temporary rates which did not include in the property evaluation the item of $M8.5 as part of the company's value by virtue of it being a "going concern". Such examples and the interpretation of expressions such as "fair value" give some idea of the legal difficulties which have affected the history of the electrical industry in the United States. Ultimately, the Supreme Court took the view that there was no separate category of industry which could be called public utilities and gave the State the right to regulate any industry in any aspect, including prices. This ruling overcame much of the conflict between the Courts and legislature and gave more power to the Government.

Another Federal body (the Securities and Exchange Commission) was authorized to regulate the issue of new securities and start the financial re-organization of the electric utilities. Holding companies were limited to the control of a single integrated system capable of economic operation. The service organizations providing management, construction etc. were required to operate at cost price. Despite all these changes, doubts still existed as to whether the private systems could be regulated to harmonize with public interests and Roosevelt advacated some public operation as a "birch rod" to control the private systems. Thus the emergence of the Federal electricity systems arose as a result of the mis-uses of corporate power and the inability of state commissions to control them. In 1940 the Chairman of the Federal Power Commission said that development of Government power policy since 1933 "may be traced directly to the failure of State regulation to find any way of establishing and enforcing sound cost and sales standards in the business of supplying the country's power requirements. To the extent that the industry sets its legal, accounting and engineering staffs to building up an elaborate justification for high costs, both capital and the industry is today responsible for its own predicament".

There were other good reasons why the Government should have been involved in electricity generation, the most important one being that such major projects as dam construction provide electricity generation plus flood control, river navigation, water resources, recreation and defence requirements. Only the Government can take these various factors into account when justifying the capital expense. Another major factor triggering the construction of many of the dams was the need to undertaking major projects as a means of combating the depression and filling the economic vacuum left by the failure of private investment. Another major area of involvement for the U.S. Government was the passing in 1936 of the Rural Electrification Act to improve on the 10% of farms which were then provided with an electrical service. By 1964 the surprisingly large total of 98% of farms etc. had been connected.

During the period following the war (1945) a considerable body of opinion was in favour of total nationalization of the industry on the grounds that it was of necessity a monopoly unlike such utilities as the railways for which alternative transport means existed. Some of the evidence was the demonstrably superior performance of many of the publically owned electrical plants resulting, for instance, in average charges nearly one-third lower in the areas supplied by the T.V.A. and Bonneville Federal systems. These outstanding examples owed a lot to low cost hydro-electric power, but in 1964 the average cost of electricity was of the order of 10-20% lower for public utilities than for the private companies. Although nationalization was considered and such alternatives as a national grid based on the British system were looked at, the policy which ultimately emerged was one of consolidation and inter-connection.

Summary and Comparison

Some comparisons and parallels can now be drawn between the U.S.A and U.K. systems. Both systems started under similar circumstances but the U.K. system faced stiffer competition from gas and constraints by the 1882 Act forbidding amalgamations. By the time this was repealed too many municipal authorities had been established to allow for the growth of amalgamations such as those in the U.S.A. under the holding companies. These amalgamations in the U.S.A. encouraged technical progress which, in turn, encouraged greater sales of electricity. The creation of the national grid in the U.K. went a long way towards redressing this balance and gave the organizational advantage to the British system, but the lack of authority for the Electricity Commissioners prevented full advantage being taken of the grid system through the forcing of unification of voltages, frequencies etc.

In the United States the abuse of the free enterprise system led to the creation of Federal Power Commission and the setting up of a different, and rival, organization. This system was regarded from the outset as being exemplary which perhaps contributed to its success. Much control of the American system is still exercised on the basis of comparisons between the Federal system and the private utilities. The regular publication of electricity costs throughout the United States is probably a more effective monitor of efficiency than any threats of nationalization. In other words, a degree of competitiveness has been brought to bear. It is worthy of note that I was often made aware of this, both in the attitudes and in the published literature of private organizations during the current research.

Perhaps the most significant evidence of the damage done by U.K. legislation is the consideration of the rate of acceleration after its removal. In 1927 the U.S.A. used thirteen times as much electricity as the U.K. In 1946 the U.S.A. used five times as much electricity as the U.K. Looked at another way the figures show that the growth in use of electricity in the U.S.A. between 1927 and 1946 was 2.9 times, whereas the equivalent figure for the U.K. was 6.1 times. However, while we in the U.K. were unifying our system the U.S.A. were consolidating and using ever larger generating units with their advantages in economy. It would seem as if the creation of the grid had been a great step forward for the U.K. and the next question to examine is whether nationalization and subsequent changes have continued the beneficial effects, or whether we have, perhaps, passed the optimum point.

CHAPTER 16

THE CHANGES IN ORGANIZATIONAL SHAPE

Introduction

The organization of power stations is the main theme of this research. The comparative study of contemporary stations has been discussed in Part 2 of this thesis. Before going on to draw some conclusions it will be useful to trace the organizational origins from the early days to the present time. I am particularly interested in the organizational structures which preceded the present C.E.G.B. ones. I shall also include a very general over-view of other overseas organizations. This latter study is very brief because little information was available and further visits, such as those to the American power stations, would not have been justified. I shall divide this chapter into two parts: 1. the development of duties and power station structures together with some information on attitudes; 2. the development of the power companies, corporations etc. There appears to be a shortage of information about life in power stations but a wealth of information about the power corporations, how they developed, their attitudes and methods of working. My main purpose is to account for some of the changes that took place after nationalization and which gave rise to the present C.E.G.B. structure.

Early power station life

The first electricity generators were small units capable of operating one arc light and one of the first of these was tried out in Blackwall lighthouse in 1857. A similar, but permanent installation was made in Dungeness lighthouse in 1862. The 1860's saw a burgeoning of installations with all the agricultural equipment manufacturers providing suitable steam engines.

In Parson's book (1939) there are quotations from a contemporary account by a Mr Chew (1880) describing the operation of one of these stations. It related to a power station installation at Blackpool for the illumination of the sea front using six arc lamps. The station was a timber building of 60 ft. x 25 ft. with two Robey 16 H.P. portable steam engines at one end and seven Siemens dynamos driven by belts at the other end. In the centre was an overhead counter-shaft belted to the engines. Each of the six arc lamps was wired to one of the machines and the seventh machine produced the excitation current for all seven. The distribution wires were slung on poles for a distance of 1,500 ft. from the station. Mr Chew then says:- "one engine man and his assistant look after the engines and boilers which require very great attention in their stoking, for a variation of 5 lbs. pressure of steam will throw all the lights out of order. Another man is kept to oil the machines and keep all going right in that department as well as to look out for any light going out, which in some cases instantly shows itself at the machines, but always on a dial board on which all the connections are made and on which we have suitable tell-tale apparatus." Since this power station would only be operating in the dark it is likely that these three men were the total staff and Mr Chew would no doubt be the engineer-in-charge. It must be remembered that steam engines were ubiquitous at that time and spares, maintenance etc. would probably be readily available.

The invention of the incandescent lamp encouraged innovative proprietors (e.g. of restaurants) to install the necessary steam engine and dynamo in a suitable outbuilding. One such installation was at the Grosvenor Galleries commissioned in 1887 and for which Parsons gives some descriptions of the duties and skills required. The standard layout of engines, counter-shaft and alternators was used but because of the variable nature of the load, there were frequent changes in the number of engines required to drive the generators. Pronged clutches were provided on the counter-shaft and the engine man had to run up the additional engine until its speed exactly matched that of the counter-shaft whereupon he could insert the prongs of the clutch and pick-up the load. Also at this station the average daily consumption of coal was

23 ton. and load was provided (to a greater or lesser extent) for 24 hours a day and seven days a week. It appeared to be a common practice to shut-down all the boilers at this type of station for a period of about three hours every Sunday.

Some of the tribulations of engineers in these early power stations were described in letters by a Mr Holbrow and Sir William Tritton (1934) both of whom were engineers at the Manchester Square Station in 1894. These reminiscences related to the operation of the earliest steam turbines and recalled that the blading was often damaged due to whipping of the shaft or by carrying over of water with the steam. When this happened it was generally possible to carry on operating until a convenient time and then the set could be partially dismantled, the damaged blades removed, and a set made available for the next evening's load. During this period they had a double shift of 'bladers' who could often only get at their work at stated times or weekends. But this was a considerable improvement on the reciprocating engines which suffered substantial damage if water came over with the steam involving long and costly repairs.

He also described how it was possible for the turbine driver to keep operating with a hot bearing by covering it up with cotton waste and circulating cold water over it. When it got so hot that it started to smoke they used heavy cylinder oil which either cooled it down or made the engine room unbearably smoky.

Sir William Tritton recalled "shortage of boiler power. With forced draught we usually had a plume of flame 20 ft. long at the top of our chimney shaft, (120 ft. high) much to the consternation of the local house-holders." During such conditions the steam pressure would be continuously falling and when the steam relay ceased to function it was common practice to hold it open with a cork or tying a weight to the starting lever. Under such conditions turbines could keep on operating long after reciprocating engines would have been useless.

The original alternators had their conductors held down by piano wire binding. When the armatures overheated the piano wire frequently fractured and was forced out of the ends of the machine. At such times there was a lot of wire whipping around and a good deal of fire flying about. The men in charge got to know by the variation of the hum of the machine when a burn-out was likely to occur after which a man was kept at the stop valve ready to shutdown and no-one else was allowed to be near. Armatures were frequently burnt out and were rewound on site. The 'winder' was encouraged by being given a bonus if the armature would stand up to use for twenty-four hours. They were normally expected to last for a month or two. After about eighteen months many of these problems were overcome. After a disastrous fire which burnt out the engine, boiler-house rooms and switchboards and which took twenty-two fire engines to extinguish,part of the plant was back in service the same evening.

Sir William Tritton described the difficulties of balancing the armatures which had a critical speed needing to be passed as quickly as possible otherwise the sets "started walking down the engine room". As can be judged from the descriptions, the power station engineers were initially eminently practical men required to make decisions and probably the forerunners of our shift charge engineers. It is interesting to note that within a very few years of turbines being invented we had 'turbine bladers' and 'armature winders' for plant maintenance. Since no such trades could have existed for long, this must surely have been a case of giving the job to someone with the necessary skills and aptitude and then giving him a "label" to acknowledge his special skill or area of work.

A distinguish continental electrical engineer of that time visited British power stations in 1894 and some of his comments are a fair indication of the current stage of the art. The following are quotations from his article:- "Let us visit one (London Central Electricity Station) at random, no matter which, as they are almost all of the same stamp. An unimposing entrance, a gloomy little back alley, and at the end the workshop of the station. A covered passage , broad enough to allow a coal cart to pass, traverses the workshop. On the left hand side, we will say, is the coal store, and to the right of a few steps, we find the boiler room. I call it a boiler room for the sake of the word. There is a long row of Babcock and Wilcox boilers arranged along the passage with a few yards between them and the wall. Proceeding in the same direction, we enter the engine room. Along the wall, separating it from the boiler room, there are installed parallel to the boilers, half a dozen or more Willans engines coupled to as many stout bipolar dynamos mounted on the same bed-plate. On the wall facing us is the switchboard. Into the engine room a grey light falls from the skylight, the walls are grimy and between one machine and the next, or the wall, there is hardly room enough to pass .... To complete the description of one of these stations, I should say that there is always a double battery of accumulators; that the distribution is on the three wire system, and that the capacity of the stations varies from 60,000 to 100,000 incandescent lamps."

Many of the early power station engineers were innovative and some, such as Ferranti, established manufacturing businesses to develop their own improvements or ideas. Others were approached by investors and asked to design, build and commission new power stations. Many of these ended up on the board of directors of such companies. Others, including some academics, became consultant engineers and these were much used for the design of power stations for municipal authorities. They also frequently carried out installations overseas.

Power station "sets" were generally available off the shelf and in the very early days the "power stations" could be operating within a few months of the idea being mooted. The later "central stations" such as the one described, generally took about two years from the idea to the operation.

Staff levels and conditions

The total numbers employed in the electricity industry increased rapidly but very much less than the increase in capacity. The following figures from Hannah (1979) gives an indication of this increase:-

In 1907 number employed	=	20,000;	Total capacity = 960 MW
In 1922 number employed	=	36,000;	Total capacity = 3,036 MW
In 1938 number employed	=	109,000;	Total capacity = 9,365 MW

The proportion of the workforce in the power stations fell from 45% in 1922 (equals 16,200) to 18% in 1937 (equals 18,700). Thus a three-fold increase in output required only a very small increase in total staff numbers.

Between 1919 and 1939 wages were equivalent to 17½% of production costs. In these years most of the companies had between 100 and 1,000 staff and most would therefore be known by the chief engineer. The bigger corporations and companies would have between 3,000 and 5,000 staff.

Class distinctions in power stations were well established before 1926 when the station superintendents or resident engineers who kept the plant operating were already members of the E.P.E.A. It was also interesting to note that during the inter-war years the unions pressed for productivity increases as the men per MW figures continued to fall. The pressure (and militancy) of the union (E.T.U.) and the capital intensive nature of the industry resulted in the men being paid above the national averages till the late 1930's when the labour surplus became a labour shortage due to the needs of rearmaments and higher rates of pay were offered outside the generating industry.

During the years in which the Central Electricity Board (C.E.B.) constructed and operated the grid the rationalization of generation caused the closure of many power stations. This caused some redundancies and compensation was normally paid. It was also the practice to pay pensions to many industrial staff, these being equivalent to half pay after 40 years service.

The engineers (i.e. members of the N.J.B.) were regarded as potential strike breakers by the Government and were also considered as being indispensable for the operation of stations. Pay and conditions of service were always good and the promotion prospects were high. The N.J.B. traditionally progressed to all the senior posts in the industry. It was also common practice for the top posts to be paid more highly in the power companies than in the municipal authorities.

During the war the electricity generated was 40% greater than the pre-war figure and the power station labour force increased by only 6,000 staff. The administrative staff were reduced by 5,000 and those engaged in distribution reduced by 31,000. Also during the war the level of unplanned winter outages increased from 6% (pre-war) to 17% and this was put down to skimped maintenance. One other interesting point is that some undertakings had a high proportion of temporary staff, e.g. in Leeds one-third of the staff were temporary. This is another interesting link with the current practice in the American stations.

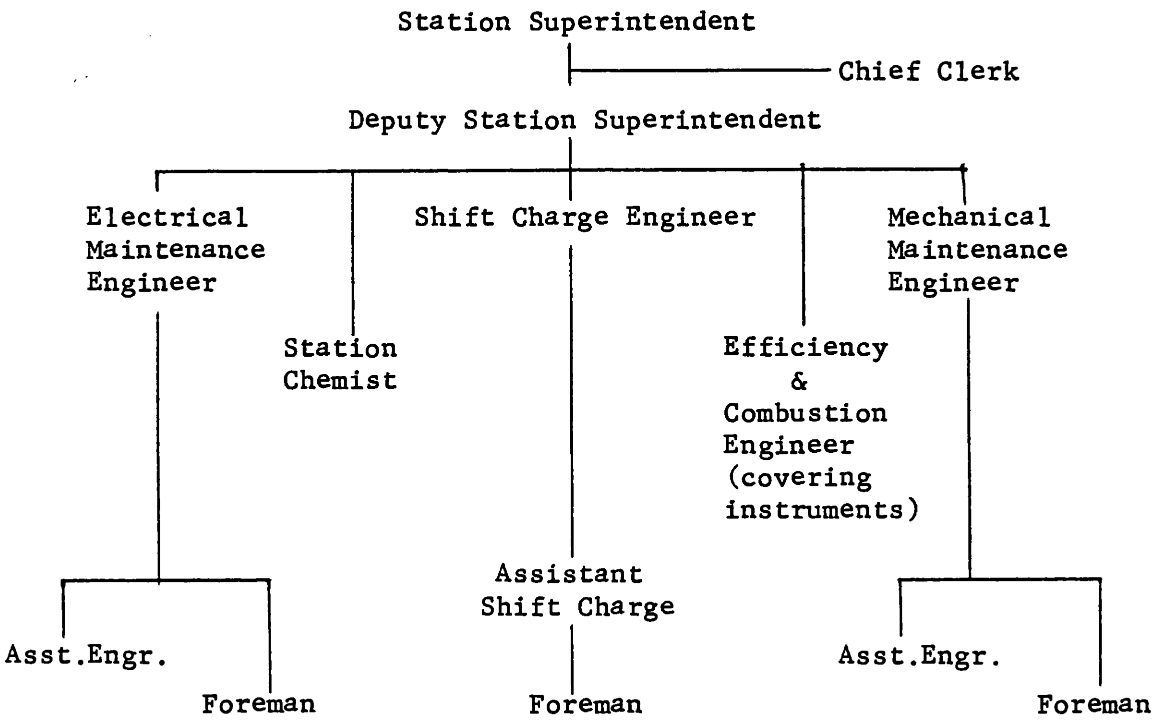
Some pre-nationalization structures

Most of the pre-war stations had all the boilers linked to one steam main from which all the turbines drew their requirements. This enable a greater degree of independence to exist between the boiler house and the turbine house and this sometimes manifest itself in organizational structures as follows:-

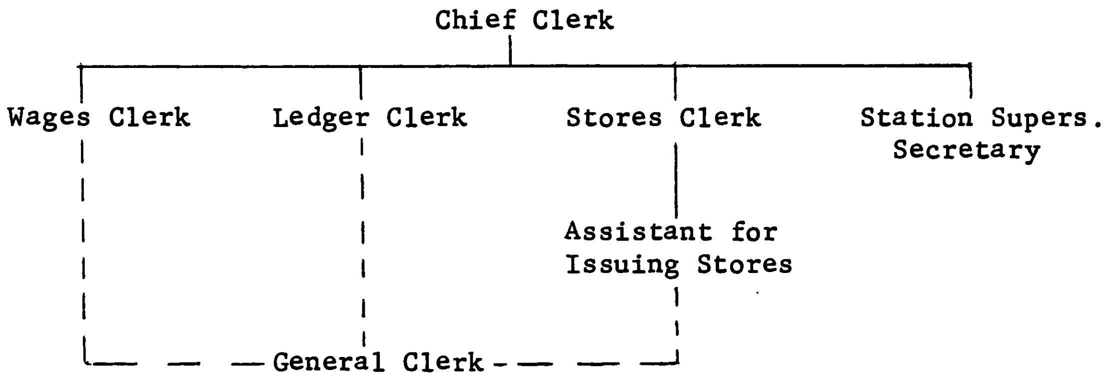
- Station Superintendent
  - Deputy Station Superintendent
    - Boiler House Superintendent
      - Assistant Engineer
    - Shift Charge Engineer
      - Assistant Shift Charge
    - Turbine House Superintendent
      - Assistant Engineer

In the shift teams the shift charge engineer tended to have responsibility for the turbine and associated equipment and the assistant shift charge dealt with boiler plant problems.

The organizational structure of one power station and some of the functions was described to me by its ex station superintendent. This was Upper Boat which first started operating in 1902 and finished in 1971. The organizational structure was as follows:-



In the early power station days the chemist and the efficiency and combustion engineer were combined into one post. When the two were formed they generally worked closely together. The co-ordination of the electrical and mechanical maintenance engineers was carried out by the deputy station superintendent but he was regarded as superfluous even in the early days. The station superintendent said it was not normally regarded as a post for promotion to station superintendent and most deputies remained as deputies to the end of their working lives. The efficiency and combustion engineer was the technical advisor to the station superintendent and kept him informed of the technical state of the plant. In some power stations instead of a mechanical maintenance engineer there were turbine room and boiler house engineers and each would have an assistant and a foreman. With this arrangement the electrical maintenance engineer always covered the whole of the plant. The mechanical maintenance engineer's assistant carried out the planning for the year's overhaul. It is again interesting to note that the instrumentation was covered by the efficiency and combustion engineer and the practice is continued in the present day American power stations. The chief clerk had a small team working for him and comprised as follows:-



The chief clerk supervised the staff and the ordering of stores which were obtained directly from the suppliers. (The engineers decided on the stockholding.) The chief clerk was also the personal assistant to the station superintendent and was responsible for making up the station books and station ledgers. The wages clerk kept the pay records and prepared the pay packets for nearly all the staff. (My informant said that even station superintendents were sometimes paid with a weekly cash packet.) The ledger clerk kept all the station accounts under the supervision of the chief clerk. The general clerk assisted all the others by carrying out filing, dealing with the mail etc. The telephone operator was a part of the distribution network control room and therefore not a member of the station staff.

There were annual meetings between the Edmundsons headquarters staff and power station staff at which the operating statistics and the accounts and costings for the year were dealt with. Tight cost control was maintained and all ledgers were inspected. At all times the station was on top of its maintenance requirements and had 90% availability between 1940 and 1948. One other point worth noting is that there was no shift maintenance staff and if anything untoward happened during the night an engineer was called out and he, in turn, obtained the necessary support staff.

This station superintendent also said that the advent of the grid made an enormous difference to the stations. Before this they had responsibility for the frequency and the time control but afterwards these responsibilities became part of the grid control. The stations under Edmundsons were free to order equipment and take-on staff and also free to determine staff levels. Their headquarters hired and fired the station superintendents. The shift staff progressed from the lowly posts at least as high as shift charge engineer in much the same manner as is currently carried out in the American stations. Craftsmen were also expected to be competent and they took a pride in their work. The foreman would normally tell the appropriate craftsmen that a piece of equipment needed attention or should be overhauled. No other information was required. My informant said that most craftsmen would feel insulted if anyone tried to tell them how they should set about the job. Note: a number of the staff at Ash Haven Power Station who were interviewed as part of the attitude survey had previously worked at Upper Boat Power Station. They all confirmed the picture here presented and held the station and its standards in high regard.

This type of power station structure continued after nationalization and the only major changes were those introduced with the pay and productivity scheme when a planning department was created comprising one planning engineer, two assistant engineers and one general assistant engineer. In addition, there were two planning clerks and four work study assistants. Additional foremen worked in the office on a rotation basis similar to that described for other stations.

There were notable departures from some of these structures and Fulham Power Station was an example where the earlier practice of generator drivers and boiler operators emerged as boiler house and turbine house superintendents each with line responsibility for all aspects of their plant and both reporting to the deputy station superintendent. Separate from these were a team of shift charge engineers who operated the plant and a group of maintenance engineers providing electrical, mechanical and instrument maintenance services. This station also had a works office where planning, programmes and work study facilities were available. The station chemist was also separate and provided a service, thus giving eight individuals reporting to the deputy station superintendent in addition to the station clerk. The structure was unusual insofar as line responsibility for the plant devolved on the boiler and turbine house superintendents (with negligible support staff) and the bulk of the remaining station staff were all regarded as providing various services to these two individuals. This pre-war structure has some interesting parallels with the proposed new structure for Olliton Power Station where engineers within the engineering services department have line responsibility for specific plant items including the responsibility for advising operation staff on technical aspects of operations.

Before nationalization the station superintendents were much more accountable and had greater responsibility than is now the case. This responsibility and accountability was further reduced in recent years when the group managers changed their role from that of advisors to that of holding line authority.

Early company organizations

The very early history of companies was almost synonymous with that of power stations. A typical example was the Kensington Court Electric Light Company which was registered in 1886 with the object of supplying electricity to the residents of Kensington Court. The plant was designed and operated for the three years by R E Crompton & Co. and was first housed in a temporary wooden shed and started operations within about six months. The permanent station equipment was housed in a large basement and the scheme's success led to a demand from other parts of the area. The company was re-registered as the Kensington and Knightsbridge Electric Lighting Company in 1888 and established a second power station in 1890. Growth continued but in 1898 it was realised that an additional power station would be required. The adjacent Notting Hill Electric Light Company was in a similar position and the two companies built a joint station at Wood Lane. This started operation in 1900 and enabled the Kensington Court Station to be closed down. The company, together with most other companies in the west of London then joined together to establish the London Power Company under the Chairmanship of George Balfour to build a large new power station at Battersea.

Such mergers of the small private companies were commonplace in the early days but were not so readily available to the municipal authorities. The adjacent power companies sometimes offered to provide a bulk supply to the local municipal authority but this placed the municipal engineer in the difficult predicament of either advising his committee that it would be financially beneficial and thereby talking himself out of a job or by making a case for the continuing operation of his own plant. The growth of most municipal undertakings was limited by the boundary. There was therefore a tendency for municipal authorities to "fudge" their accounts to present the undertaking in a more favourable light.

Some political overtones coloured the progress since there was a genuine fear of the power companies exercising the same sort of monopoly power as had previously been experienced with the railway companies. Increasingly the municipal authorities were supported by the Liberals and Progressives and the power companies were associated with the Conservatives.

In the United States and on the continent the integration of the municipal and power companies progressed much more satisfactorily due to the willingness of the power companies to offer shares and seats on the Board to the municipal authorities taken over.

It was also reported that power companies were considered to be more efficient, their labour more productive and the salaries of their senior men were greater than the equivalent municipal salaries. The municipals tended to pay the manual workers more than the power companies. Many of the power companies had links with manufacturers similar to those in the United States and did not operate on the lowest tender basis. This practice was confirmed by my ex station superintendent informant. It was also generally considered that the power companies were less bureaucratic than the municipal undertakings.

Developments under the C.E.B. Under the C.E.B., power stations generated in accordance with the strict merit order but all the power stations on the approved list had their costs covered by the C.E.B. Over the years during which it was in operation the power companies obtained a larger share of the new generating capacity than did the municipal authorities and since both were installing new plant this implies that the power companies were able to operate it more efficiently and at lower cost.

My informant said that Edmunsons had a central construction department responsible for designing and erecting the power stations. They also had responsibility for any plant modifications and he described how as a young engineer he was asked by a head office design engineer over the telephone to inspect a certain part of the plant and confirm that there was a way through for an additional pipe. He carried out the inspection, couldn't see a way through and notified the engineer. The engineer, not convinced, came to the station and pointed out (from a most peculiar angle) that there was indeed a way through for an additional pipe. He said this was typical of the close contacts and knowledge of their power stations by the headquarter's construction division. The reader will also be aware that it closely parallels my experience during the visit to the Marshall plant.

During these years there was evidence from overseas power stations that British power station productivity could be increased. However, with the high unemployment levels then prevailing, many municipal authorities preferred to maintain employment levels. The power companies generally made manpower savings and were able to increase their profits by using the less efficient municipal undertakings as yardsticks. The Electricity Commissioners always had their suspicions that this was the case but evidence was hard to comeby since the rate of return on capital was reasonable. What was unknown for many years was the actual cost of the capital and the fact that this was raised at high cost from selected investors. For example, a hypothetical investor in Edmundsons in 1919 would have received an average rate of return over the next 20 years of about 150% per annum. Additionally, by selling out in 1939 he would have made a capital gain equivalent to thirty times his original investment. And all this during a general period of a deflation. Such behaviour was reflected in the attitudes adopted during the nationalization period.

During the C.E.B. years the total spare capacity in the country dropped from 40% to 10% which the C.E.B. considered to be adequate. New power station construction times extended from two years in the 1920's (conception to completion) to between three and four years in the 1930's. This extension of the time required some improvement in the forward prediction of load and the seeking of ways to improve the load factor. However, the C.E.B. badly under-estimated the post-war plant requirements since they predicted the economy would behave in much the same way as after the first-world war.

Some nationalization changes Nationalization was carried out by a Labour Government which tended to be sympathetic towards the municipal undertakings and suspicious of the power companies. Under the original scheme the generation was divided into divisions to match the area boards. In the case of the South Wales division the staffing for the headquarters was drawn from ex municipal undertakings men. For example, the general engineer responsible for operations was an ex Swansea Corporation man. As already pointed out, the municipal undertakings didn't design and build their own stations but tended to buy in expertise and service from the manufacturers. We thus had the following situation:-

Power Companies
(designed, built
and operated own
stations)

Municipal Undertakings
(bought in skills and
operated stations)

NATIONALIZATION 1948

C.E.A. (B.E.A.) Divisions bought in Power Station design etc. Expertise of the old companies was lost. Typical of the result was Uskmouth 'A' Power Station. This was the start of the split between the construction headquarters services and the stations. The London headquarters design department maintained a liaison with the divisional headquarters.

1957: RE-ORGANIZATION
ESTABLISHMENT OF C.E G.B.
REGIONS

These events have been set out in the form of a diagram because I believe they were very important. A number of senior staff including an ex station superintendent confirmed that with nationalization the close working links between the headquarters groups and the power stations were broken mainly because the municipal men (with certain exceptions such as Birmingham) were not experienced in designing, modifying or operating their stations. Operational responsibility rested with the station superintendent (or resident engineer) who might (or might not) have a chief engineer in the council. Ultimate authority rested with the council committee who were amateurs and seldom had the continuing commitment or expertise such as would be displayed by the Board of Directors of a power company. This expertise was regarded with suspicion by the nationalizing Government and many power company men were bitterly opposed to nationalization. Not surprisingly, the managerial abilities of the power companies tended to be overlooked in the restructuring following nationalization.

It was interesting to note that following the establishment of the C.E.G.B. regions,the C.E.A. divisions then attempted to more closely identify with the power stations in an endeavour to justify their continuing existence. Many examples existed of duplication of effort by divisional and regional staff. The original intention had been to have a small regional holding body with the divisional officers providing certain services. Eventually the decision was made to shutdown the divisions altogether and transfer the staff to the regional headquarters.

Other post C.E.G.B. changes As already mentioned the regions were created and the divisions closed down. Design of power stations was assigned to three project groups and additional research facilities were created. Power station organizational structures were almost all of a standard format, namely; operation and maintenance superintendents together with a station administrative officer reporting to a deputy station superintendent and through him to the station superintendent. Many stations had staff numbers in excess of 1,000, a major cause of these high figures being the reduction of overtime. At this time the rates of industrial pay within the industry were lagging behind outside industry and overtime was a means of boosting pay. Weekend working at overtime rates was the accepted practice. The introduction of the pay and productivity scheme led to the substantial enlargement of headquarters planning departments whose job was to devise and implement schemes for each of the power stations. When all the schemes had been implemented the falling headquarters workload was offset by the advent of corporate planning together with more sophisticated manpower planning services from the personnel department.

In the power stations, development teams were created to handle technical problems of the new 500 MW units and these have already been described. Also described are the planning departments which were created, or greatly enlarged, to facilitate the scheme. Shift maintenance was introduced, or became proportionately greater.

Brief notes on overseas systems

Although the French system is nationalized, a quarter of the total generation is still outside the E.de.F. The German supply industry is similar to the U.S.A. one, with nine large private companies supplying the bulk of the electricity and operating the distribution systems. Certain large municipalities distribute and generate their own electricity but many small undertakings buy bulk electricity from the big companies. The Swedish system comprises a State owned company generating about half the electricity with the other half produced by municipal undertakings and private companies. The main transmission network is owned and operated by the State. In Holland the system is privately owned but the Government body grant licenses and monitors it. An association of the largest producers owns the main transmission network. The Danish industry is half owned by co-operatives and half by municipalities with power stations generally constructed as joint ventures. The State monitors the system. The Belgian industry is a mixture of privately and publically owned undertakings with some power stations owned by groups of industries. In Italy the State operates 80% of the national generating capacity and the remainder is mostly private industrial plant: each of eight regions has responsibility for the construction and operation of the plant and distribution of electricity. The Polish system is nationalized and divided into six regions each responsible for generation, transmission and distribution. Finally, the Russian system is not inter-connected and comprises fifteen smaller systems. Overall policy is determined by a Minister of Power but some individual republics have responsibility for their own system and three have their own Ministers of Power. The total installed capacity is second only to the U.S.A.

CHAPTER 17

CONCLUSIONS: WEAVING THE STRANDS

Preamble

On reaching this stage in the thesis I find myself in a similar position to that Joan Woodwood at the end of her survey of the industries in south east Essex. She and her team had conducted 800 interviews and had a mass of data sufficient, as she said, to write a manual about each of the companies involved. I too have masses of reported data and wonder whether I have missed out blocks of information which are important and might have given a better insight into life in power stations.

Should I have explained the background circumstances of many workers at Olliton Reach Power Station (Chapter 3) the grinding poverty they had known as children which made them determined above all else to ensure that their children should not suffer in the same way? As a result they were interested in working, earning money and "moonlighting". And have I made clear the fact that inferior plant is most strongly reflected in work stress for the mechanical maintenance departments since electrical and instrument equipment tends to work or stop? Mechanical equipment often continues to function in an unsatisfactory manner and requires a continuous work input.

What about the role of the station managers? Within the study the most unsuccessful station was Ash Haven. But the station manager at Ash Haven had a mechanistic approach and did his best to follow the procedures and systems devised and introduced by Regional Headquarters If those systems are unsuccessful the station manager will be blamed, if they succeed the headquarters staff will be pleased to take some credit. This is rather like the old fashioned physicians who advised the barbers on how to perform surgery and took the credit when it was successful and blamed the barber when the patient died.

Should I have reported on the autocratic nature of the Board's Chairman (in office during the survey) and the fact that no-one dared to disagree with him? Such an attitude works in communications in much the same way as a one way valve in engineering.

To have started upon a discussion of bureaucracy would have been too vast an undertaking. Is one of its greatest failings a lack of sensitivity and is that its "Achilles heel". Solzhenitsyn in the Gulag Archipelago (1974) made the point that the K.G.B. repressive machine was the system for removing dissidents but strictly within the law. Many of the cruelties and tyrannies were "unofficially" enacted in order to achieve the systems aims. Solzhenitsyn mused, on hearing that one of his fellow army officers was in the K.G.B., as to whether he too might not have been on the other side had he taken a slightly different career path at one point.

In their research into working conditions in a chemical process industry, Nichols and Beynon (1977) described working conditions within a chemical plant every bit as brutal and degrading as those prevailing about a century before and which were the subject of many of our social reformers writings. How can these anachronisms exist within enlightened companies? Why were many of the jobs at Ash Haven unnecessarily dirty and degrading? I would suggest the answer lies in the substitution of systems and procedures for communications and contacts. The previous paternalistic station manager at Ash Haven saw the site, experienced the working conditions and would not tolerate unreasonable conditions for the staff. He also saw any slackness or scrounging and would not tolerate those either. These are the two sides of the coin of personal contact and I would suggest its a far better form of currency than the paperwork of job cards and complaints procedures.

I shall now try to pull together the various strands of this research, link the comparisons made in Chapter 9 between the C.E.G.B. and United States systems with the earlier forms of power station management within the C.E.G.B. I shall also try to bring in some of those factors which have emerged from a brief review of the industry's history. It will be convenient to deal with the subject at three levels and I shall start first with the organization of the electrical industry in the various countries before summarizing the information obtained in relation to power stations. Finally, some of the findings and conclusions relating to individuals within the power stations will be presented.

The Industry

Historically, the industry in this country had much in common with the European and United States industries, it being a mixture of power companies and municipal authorities. Amalgamation and growth were more readily achieved in Europe and the United States because of the greater co-operation that existed. In both the U.S. and the U.K. (and possibly in Europe) the fear, or reality, of excessive profits gave rise to a need for curbs. In the U.S. this took the form of Federal undertakings (T.V.A.) plus some Federal controls. In the U.K. the C.E.B. provided control plus an effective integration by the use of the grid. This automatically provided constraints to the power companies since excessive profits would have priced them out of the merit order. (Unfortunately the Clause 13 curtailed this power.)

The C.E.B. was then a non-profit making broker with a very limited potential for bureaucratic growth since it only owned the grid system. Responsibility for the construction and operation of power stations rested with the companies and the C.E.B. provided the efficiency incentive.

The surprising feature to emerge from the study was that the more efficient power companies in the U.K. before nationalization had organizations very similar to their contemporary U.S. counterparts. One of the common features of both was the design and construction divisions which also took a continuing interest in the operation of the power stations. The nationalized E.de.F incorporated a similar organization within their structure but the B.E.A., C.E.A. and finally the C.E.G.B. created design departments with no direct links to the power stations. (Quote by project engineer "we have no system for communicating with power stations"). This fact, according to many comments, immediately led to a drop in the construction standards (e.g. Uskmouth Power Station) and the lack of liaison has perpetuated faults to the present generation of power stations (e.g. Fossil Strand feed pumps).

Another failure (according to the Government's Select Committees) was the industry's forward planning and its inability to predict the future load,compounded by the failure to anticipate the manufacturers inability to build the stations required. In the United States the practice of larger companies building their own stations acts as a buffer to such changes in demand and therefore these failures may also be partly due to the loss of a design and build capability.

On the positive side, the centralizing of design and construction service should enable standardization to take place. The lack of such standardization was the cause of much inefficiency in the drive for new generating capacity immediately following the war. However, the C.E.G.B. project groups did not use the strength of their purchasing power to insist on design standardization. As a result, the C.E.G.B. probably has more prototype plants than the U.S. with its much smaller organizations. There were five turbine and eight boiler designs in the 500 MW programme and very few identical stations out of the forty-six units supplied. A similar situation exists for the A.G.R. power station programme. The inevitable corollary is the need for more spares, the more rapid obsolescence and more engineering manpower to solve technical problems. All these problems associated with operating power stations arise from the failure to have an effective design department.

The Board's practice of accepting the lowest tender was defeated by the creation of manufacturers price rings. The Duke Power Company system of single tender action for major items of plant appears to give it far more power over the suppliers than the C.E.G.B. system. At the T.V.A I was also given evidence of the delays (and losses) arising from the use of the lowest tender system.

The cash flows associated with modern power stations can turn any savings arising from the lowest tenders into losses if delays arise. From information I was given it would seem that there was a far greater awareness of the importance of saving time in the period before the advent of planning systems. Currently, the loss of a day's production from Fossil Strand 'B' Station is equivalent to £M½. On this basis the industry should be considered as time (or profit) and not capital, or labour intensive. i.e. The cost of labour and and materials are unimportant, time matters. The French and U.S. industries appear to be more aware of this and seem to end up with much more reliable plant.

In the pre-nationalization days the station superintendents exercised far more autonomy but cash flows and performance data were closely monitored by headquarters to whom the station manager had to account annually for his stewardship. I have estimated that about 80% of the regional headquarters effort is devoted to monitoring power station performance. With twelve hundred staff devoting their efforts to seven major stations this is likely to reduce the sense of autonomy of the station managers.

Many Government committees (including Plowden) were disturbed by the C.E.G.B.'s monopoly and considered various ways of attenuating it. Most investigators seemed to accept that the size of the C.E.G.B. was a desirable virtue and yet the study of overseas electricity organizations indicates that no other country has such a monolithic structure. If size were such a virtue one would have expected some of the smaller countries to have encouraged a single generating organization and yet this is not generally the case. Plowden envisaged difficulty in transferring electrical power from one generating body to another if the generating regions were made autonomous. However, electrical power transfers are commonly practiced in the U.S.A. and in Europe and such transfers seem to lead to greater co-operation between undertakings rather than the exercise of undesirable pressure as feared by Plowden.

Some re-organization with the aim of breaking up the absolute monopoly of the existing C.E.G.B. would seem to be necessary and the Chairman of the U.S.A. Federal Power Commission would seem to be correct when he said "the lack of effective competition (monopoly) leads to high costs". This sentiment might well be borne in mind when considering the industry's re-organization. Permitting favourable terms for private companies to generate their own electricity and sell any surplus was included in the Re-organization Bill of April 1978 which was defeated in Parliament.

The power stations

The most striking facts to emerge from the study of power stations is the very close matching that existed between the pre-nationalization U.K. power station's organizational structure at Upper Boat and the present structure at the Marshall plant in the U.S.A. These similarities are so striking that they are worth re-iterating:- test and efficiency combined with instruments; no shift maintenance; planning associated with mechanical maintenance; minimal clerical services; a run through for operations staff up to shift charge engineer and a deputy station superintendent at Upper Boat who was considered (by the station superintendent) as being an unnecessary part of the organizational structure. Another close comparison can be made between a U.K. pre-nationalization power station and the Marshall plant. This one, like Marshall, had four coal-fired units, but they were 30 MW each. This station (Llynfi) had a 166 staff which included the planning department for the productivity scheme compared to the 168 at the Marshall plant. In both cases cleaners and the gatekeepers were excluded. Sixteen of the Llynfi staff were directly attributable to the productivity scheme. Another surprising factor in a comparison between the Marshall plant and pre-nationalization U.K. stations was the consistently high availability levels achieved by both and both were at all times in command of the maintenance workload. These figures raise questions about the C.E.G.B.'s practice of equating efficiency with men/MW. Perhaps the manpower levels should be related to the number of plant units plus any additional staff arising from inferior plant (needing too much maintenance) or superfluous systems such as the short-term planning. Certainly in the inter-war years the electricity industry in the U.K. took this view and the industry's capacity trebled with very little increase in total staff.

Analysis of duties and attitudes in C.E.G.B. power stations indicated that work output was approximately 50% and evidence was given by planning engineers that a great deal of work was "created" to fulfil the requirements of the productivity scheme. There is also the evidence from the Fossil Strand survey that half the work was considered to be unnecessary by those prople who carried it out. Other evidence, particularly from Fossil Strand, indicated a substantial overlapping of engineering duties in relation to plant items or plant systems. One senior engineer gave it as his opinion that the numbers of groups, teams and individuals performing functions in relation to the plant was so great that it was impossible to co-ordinate and manage the activities. This type of picture with over 300 engineers at Fossil Strand contrasts sharply with the 37 engineers (including temporary appointments) on site to commission the 2,300 MW nuclear station at Sequoyah.

All these facts add together to indicate that comparisons between C.E.G.B. power stations and American ones produce similar results to comparisons between the current C.E.G.B. power stations and pre-nationalization ones. Another interesting factor to emerge was that during the war-time emergency the increased frequency of plant breakdowns was attributed to skimped maintenance. According to fitters at Ash Haven Power Station the productivity scheme times allocated frequently led to skimped maintenance and it was their opinion that many recurring defects arose because of this factor. Others arose because of the low standards maintained on the site. Although the plant at Ash Haven 'B' Station appeared to suffer from manufacturing defects or design shortcomings the 'A' Station plant had once been considered to be some of the best in the C.E.G.B. Its age was not too different from that of the older Marshall plant whose availability was over 86% in 1976.

The high maintenance levels at the newer C.E.G.B. stations are probably attributable to the plant design defects which have already been discussed. The excess of work planning,which had no parallels in overseas stations, or earlier U.K. stations, was attributable to the Board's implementation of the productivity scheme proposed by the National Board for Prices & Incomes. However, the CEGB failed to discontinue the system when productivity reached 100% as had been recommended by the N.B.P.I. As a result, these systems have become institutionalized giving rise to unofficial systems in order to ensure that such important matters as work priorities can be continued. The irony is that those stations most closely adhering to the formal schemes appear to be the less successful stations. However, in the case of Ash Haven, it would be difficult to evaluate the various effects of poor plant, irrelevant systems or misguided management.

The study of the power stations did not support Woodwood's findings in terms of hierarchical levels in organizations and the complexity of the organization (and its size) seemed to owe more to the number of systems imposed than to the technology.

Effects on individuals

In the U.K. the division between engineers and industrial staff is as old as the industry and probably part of the social fabric. In the early power station days the number of engineers on a particular station would be very few and they would invariably combine the functions of manager with those of engineer. (Apart from junior posts.) This factor probably minimized the resentment of the industrial staff. Considerable resentment was detected at Ash Haven and Fossil Strand due to two main factors which were:-

(a) Engineers frequently carried out duties which were within the province of the skilled fitters, and

(b) Many engineers in the support services (e.g. planning) were in "non jobs" and were therefore not respected.

Another major cause of resentment is the fact that the N.J.B. staff pay rates are substantially greater than the rewards for equivalent skills outside the industry whereas the industrial staff pay rates were lower than those prevailing outside the industry. This latter situation seems to have arisen since nationalization as throughout the inter-war years the power station industrial staff were paid higher than outside industry in general. During the war there was a relative slip in pay but this was no doubt compensated by the extremely long hours worked. It was therefore beholden on the newly nationalized industry to restore the pay differentials appropriate to the higher grade staff expected, and necessary, for the capital intensive, high merit process industry. In the U.K. this was not done but the research evidence shows this was the policy of some American companies (Detroit Edison). Because of the low pay, overtime "rackets" became rife and these led to greater discontent and over-staffing when they were bought out. This in turn was followed by the productivity scheme with all the inefficiency it caused. However, it at least restored the pay levels to parity with outside industry.

The effects of the productivity scheme were probably the greatest cause of discontent for the staff interviewed and these were exacerbated by the remote management at Ash Haven.

The difference between the treatment of a craftsman at Upper Boat ("he would be insulted if anyone tried to tell him how to do his job") and the working patterns at Ash Haven ("split the job into three cards, dismantle, repair, re-assemble and the total time is doubled") and the reason for the loss of motivation becomes apparent. This loss was expressed by many staff who said how much they disliked dropping, or taking-up a job half-way through. The whole concept of the productivity scheme was seen to be closely in accordance with the principles of scientific management and therefore resulted in subsituting a hygiene factor (pay) for the loss of a motivator (job satisfaction) to use the terminology of Herzberg. Although the scheme is now to be discontinued in the power stations it is proposed to carry on timing jobs and to carry on with the planning. If these proposals are put into practice there is little prospect of any improvement in motivation or morale in the power stations.

The research into the pay levels at Ash Haven provided the disquieting information that the average member of the industrial staff had 15% less disposable income than he would have received on supplementary benefit. I considered this finding to be so significant that I have gone into it in greater depth in Chapter 11. This shortage of pay made overtime working very desirable but the Board's policy was to generally withhold this and the overtime available at Ash Haven was unfairly distibuted. It was significant that the United States power station policy was to allow overtime and average levels of about 15% were normally worked.

Shift work was tolerated but not liked by those who carried it out and weekend working was also generally disliked. In the United States stations weekend working was confined to one weekend in two and shift working was minimized. At the C.E.G.B. power stations weekend working was generally maximized because it was a means for obtaining additional pay even though in many cases it was unnecessary. Also, shift working was sometimes maximized on stations and all stations carried out shift maintenance to some extent. Neither the American or French stations (nor the pre-war U.K. stations) found shift maintenance work necessary.

The overseas practice of bringing in additional staff for the major outages ensured a much steadier workload for the station staff. Despite being staffed for all major outages, most C.E.G.B. stations find it necessary to take-on substantial additional numbers in the form of contractors and the disparity between their pay rates and the station staff pay rates causes further discontent. It also raises the question of the degree of over-manning in C.E.G.B. power stations if they are theoretically able to handle the peak workloads associated with major outages. These two topics of shift work and overmanning are both dealt with in more detail in Chapters 10 and 12.

Summary of post nationalization problems

Before summarizing the main steps leading to the differences between the present U.K. and U.S. power stations one fact ought to be stated. The C.E.G.B. provides the most reliable and stable electricity supply in the world. This research is about how that is done and at what costs, but the fact of that achievement is not questioned.

The research has shown the pre-war U.K. power station practices were the same as the current U.S.A. ones. It might therefore be predicted that without nationalization, U.S.A. type organizational structures would now exist in the U.K. power stations. The differences appear to be attributable to a sequence of factors following nationalization.

1. The more bureaucratically inclined municipal authorities were in ascendency following nationalization.

2. The industry failed to restore the premium pay rates traditionally associated with power station work.

3. The new headquarters organizations divorced themselves from power station operation.

4. Forward planning of requirements was badly miscalculated.

5. This was exacerbated by the Area Boards policy of selling electrical heat that we couldn't produce.

6. The industry was "taken for a ride" by the plant manufacturers.

7. Dissatisfaction with pay led to weekend overtime "rackets".

8. These were 'bought out' with substantial increases in staff and no overtime.

9. The resulting drop in productivity gave rise to a decrease in staff and the bonus scheme.

10. The delayed and inferior equipment and a shortage of generating plant led to increases in engineering staff.

11. The bonus scheme work planning systems led to a proliferation of engineers, clerical staff and supervisors.

12. The loss of work control by the industrial staff gave rise to lower standards.

13. The morale of the industrial and engineering staff is low and power station availability and efficiency is substantially below design standards.

Most of the Government investigations into the industry have been concerned with finding ways of increasing the accountability of the C.E.G.B. It remains as the only single headed monopolistic organization within the nationalized industries and, to repeat the statement of the Chairman of the U.S.A. Federal Power Commission (who should know) "the lack of effective competition leads to high costs".

T H E E N D

APPENDIX

Detailed information on the work and working patterns in the power stations studied.

LOCATION STUDIES INTO WORK PATTERNS

The summarised data on jobs and working patterns from the various locations is presented. The information has been discussed and compared in Chapters 5 to 8 and this appendix provides some of the basic data. Comments and comparisons will be made in relation to individual locations in a more detailed manner than was possible when presenting the general picture. The information is set out in the same approximate chronological order as was adopted for Chapter 2.

Working Patterns in a 2,000 M.W. Coal Fired Station

This study was made in the early post-commissioning stage when a great many problems still remained to be solved on the station. Consequently, one would not expect to find the same working patterns as would exist on a steady state station. Because of the substantial number of problems associated with nearly all the new C.E.G.B. plant the only stations in the study which could be described as steady state were two of the three U.S.A. ones. The main study at this station was the work and working patterns of the engineering staff. A further study covered the administration staff and finally some useful information was obtained about general working patterns and the industrial staff. The findings are discussed in the next three sections.

Engineers' Working Patterns

In Table A.1 the objectives and tasks were summarised from job descriptions prepared by the author in conjunction with post holders or their supervisors. Each task was given an estimated percentage of total time (based on a standard 38 hour week) by the post holder in order to build up a picture of the working pattern. These percentages also gave an indication of the total time demands of the job because totals in excess of 100% were a measure of the additional time spent on work either at the location or at home. In Table A.1 the working week for each post is shown. The author made a practice of asking for how long and how often certain types of job were performed and from this deriving a total time in hours per week for each task. This was converted into a percentage of the 'standard' week. Also during the interviews the author asked about the pattern of work, including estimates of the average length of the working day, weekend and evening involvement etc. The agreement between the two calculations was generally surprisingly close and if substantial discrepancies did exist the task allocations were re-examined. This usually led to time being revised or frequencies being reduced in the case of over estimates. In the case of under estimates the post holder invariably had overlooked some routine task which took far more of his time than was expected.

Also shown in Table A.1 are two sets of percentages, each set accounts for all the time of an individual in a particular post. The total time spent on each task was divided between the elements for each set of percentages. The allocation was made by the author based on the full job description which included a statement on the working patterns. Subsequently, the elements for all the tasks associated with the post were summarised to give the figures shown in the Table. These percentages were an attempt to obtain a picture of the overall nature of the post (manager, supervisor, administrator or engineer) and also to assess the levels of urgency associated with a particular post.

The number of tasks listed in relation to a job varied considerably depending on how the post holder thought of the work. Some would attempt to itemise every task and others would say that their only task was e.g. solving technical problems on the plant. By further discussion and by grouping related tasks it was generally possible to identify between ten and twenty separate tasks for most posts and more for senior staff.

2000 MW COAL FIRED POWER STATION NJB POSTS

TABLE A .1 A SUMMARY OF JOB DESCRIPTIONS

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
X.1	M	Station Superintendent	To meet System Requirements; to optimise performance with economy; to maintain good industrial and public relations relations.	Attending various meetings with outside organisations on a wide variety of subjects, attending internal meetings with Management Team to determine policy, monitor progress and to inform staff. Attending site meetings with various staff groups, e.g. L.A.C. discussions with individual staff. Monitoring routine systems and making decisions relating to exceptions. Dealing with routine matters, visiting areas of the site, monitoring performance of staff. Thinking through policy, programmes and contemplating changes. Background reading in managerial and technical subjects. Station Manager is the "outside" man in Management Team. He also has line responsibility for the whole of the station and reports to the Group Manager.	10		58	31	73	21	27	42	55	55
X.2	P	Deputy Station Superintendent	Ensuring that site work is properly co-ordinated and carried out to achieve maximum availability efficiency and performance commensurate with economic advantage. To deputise for the Station Superintendent.	Co-ordinating meetings to deal with short term problems. monitoring work on site· maintaining good industrial relations on site. Discussing work and policy implications with the Station Superintendent and with other staff. Progressing high priority work; writing Station Monthly reports. Attending various station meetings· dealing with a number of callers. Monitoring training programmes, monitoring Pay and Productivity performance. Making technical decisions, keeping aware of current technical progress. Deputising for the Station Superintendent. No direct responsibility for other staff. Main role is internal short term management and decision making and monitoring.	8	13	51	49	38	18	30	51	44	40
M.1	P	Maintenance Superintendent	To manage and direct the resources of the maintenance department so ensuring maximum efficiency and availability of plant commensurate with safety and economic advantage.	Attending Management Team meetings. discussing policy and progress. Discussing maintenance and policy with the senior engineers. Dealing with technical information, adjusting Departmental work as a result writing instructions. letters, etc. Monitoring Departmental budgets, interviewing and recruiting new staff. Maintaining industrial relations, dealing with personal problems. Inspecting the plant, monitoring progress, giving technical decisions. [illegible] projects dealing with urgent technical problems. Reviewing systems, establishing new systems. carrying out random checks on procedures. Carrying out the duties of Site Safety. Officer, investigating incidents, promoting safety campaigns, dealing with specific problems. Background technical reading; covering for the absence of senior departmental staff. Two main roles are Member of Station Management Team and Leader of Maintenance Management Team.		16	48	45	33	11	38	33	41	53

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
M.2	S	Maintenance Engineer (L.E. & Inst.)	To ensure that all light electrical and instrument equipment is maintained at maximum availability; to organise any necessary improvements, to achieve maximum plant efficiency. To carry out work at lowest overall cost.	Discussing overnight problems with the Shift Maintenance Engineers. Discussions with Engineers during the day. Modifying daily plans to suit the plant needs, carrying out routine administrative work. Visiting the plant, progressing work, maintaining good industrial relations. Answering queries from Engineers on site, dealing with problems relating to material supplies. Preparing maintenance schedules, discussing problems with other locations, S.S.D. etc., preparing weekly progress reports. Making decisions about urgent work, checking work specifications, updating station manuals. Organising and managing specific projects as allocated by the Station Superintendent. Is a Member of Maintenance Management Team and the Daily Work Co-ordinating Group.	17	27	59	66	42	15	32	62	54	39
M.3	S	Maintenance Engineer (M & H.E.)	To maintain mechanical and heavy electrical plant at maximum availability and efficiency commensurate with safety and economic advantage. To carry out any necessary improvements to achieve greater efficiency at optimum economic advantage.	Discussing overnight problems with Shift Maintenance Engineers, proposing changes for the short term workload. Attending short term Management Meetings dealing with administrative aspects of work. Dealing with formal industrial relations with Shop Stewards, visiting the plant to maintain good industrial relations. Dealing with enquiries from Engineers, chasing suppliers and contractors for equipment, etc., thinking through long term plans for major overhauls. Remaining aware of current technical improvements, discussing problems with outside bodies, e.g. S.S.D. Preparing weekly reports on progress, monitoring systems and procedures within the Section. Checking through defect reports and arranging priority orders. Is also a Member of Maintenance Management and Daily Work Co-ordination Groups giving technical advice and making decisions.	11	45	46	41	30	3	46	48	21	51
M.4	1	Assistant Maintenance Engineer (L.E. & I; Long Term)	To assist in maintaining Light Electrical and Instrument Equipment at maximum availability and efficiency commensurate with safety and economy. Ensuring major overhauls are carried out efficiently.	Discussing the maintenance work position each day and adjusting the programme in accordance with needs. Carrying out preparatory work for major outages relating to the results of previous outages. Holding discussions with Section Staff, maintaining good industrial relations. Dealing with enquiries from inside and outside the station, also enquiries to suppliers for spares. Giving technical instruction to Foreman and Craftsmen, making [illegible] on the plant. Organising contracts and technical supervision when in progress. Carrying out modifications to telecommunications, T.V. and radio equipment on the plant. Analysing maintenance procedures and recommending changes for future work,. Maintaining liaison with Project Groups and other Departments and discussions with outside bodies. Checking completed work, making relevant entries for plant history purposes. Concerned primarily with plant problems and organising their solutions.	35	36	48	67	7	19	33	30	37	59

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
M.5	1	Assistant Maintenance Engineer (L E & I; Short Term)	Maintaining Light Electrical and Instrument Plant at maximum availability and reliability commensurate with safety and economic advantage. Ensuring that work in progress is carried out efficiently.	Discussing overnight problems with the Shift Engineers and discussing other problems as they arise during the day. Monitoring progress of work on site, maintaining good industrial relations, dealing with personal problems. Enquiring about supplies from contractors suppliers, etc, dealing with enquiries relating to the plant. Planning the following day's work with the Planning Department each day. Discussing problems relating to the plant with S.S.D. and other callers. Organising contracts with manufacturers and supervising contract in progress. Giving technical instructions to Foremen and craftsmen, making technical decisions on site. Analysing previous maintenance procedures and performance and making changes. Deals mainly with organising work in progress.	13	35	43	47	6	17	40	66	32	12
M6/10	1	Shift Maintenance Engineer (M. & H. E.)	Providing continuous technical supervision and service for Operations Staff to ensure maximum availability of plant.	Co-ordinating planning aspects and continously updating the short term programme. Advising the Foremen of the work programme and reallocating duties. Organising supplies of spares and materials, dealing with industrial relations aspects. Carrying out plant investigations, providing technical advice and supervision, dealing with technical queries, carrying out investigations and tests and checking before recommissioning. Dealing with various technical aspects relating to one area of plant. Closest links are with the operations shift team.		36	40	46	7	23	29	73	19	13
M.11	1	Assistant Maintenance Engineer (M. & H. E. Short Term)	To maintain mechanical and heavy electrical equipment at maximum availability commensurate with economic advantage. To organise and monitor the maintenance programme in the short term.	Reviewing the day's programme in the light of the shift experience. Subsequent discussions during the day in relation to progress etc. Administrative aspects, organising spares, etc. Maintaining good industrial relations, dealing with personal problems, discussing technical matters with staff. Dealing with telephone enquiries from outside and making enquiries of suppliers and other outside bodies. Planning the following day's work at the afternoon planning meetings. Giving technical instructions to the Foremen and craftsmen; monitoring the work in progress; giving other engineering and organisational guidance to the staff. Checking and monitoring completed work orders. Keeping up to date with technical progress. Main areas of work are managing industrial staff, obtaining supplies and making short term decisions.	5	41	43	38	14	24	36	66	26	20
M.12	1	Assistant Maintenance Engineer (m. & H. E. Long Term)	Ensuring heavy electrical and mechanical plant is maintained at maximum availability and efficiency commensurate with economic advantage. Ensuring that long term work is correctly programmed.	Morning monitoring of the state of plant discussing progress during the day with the Maintenance Team. Preparatory work for major outage including analysing previous outages. Frequent discussions with Planning Department engineers. Ordering spares and other equipment. discussing problems with plant and maintaining good industrial relations. Queries to suppliers about spares on order and to contractors about progress of work. Discussions with outside bodies, e.g. S.S.D., relating to problems; answering queries from staff on site.	35	33	41	51	8	14	34	50	21	36

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
(cont'd) M.12				Giving technical instruction to Foremen and Craftsmen and engineering guidance relating to the work in hand. Making technical decisions on the plant. Organising and supervising contracts on plant. Attending various meetings on site, e.g. L.A.C. Main work areas are determining technical content of outages and organising contractual work.										
M15	2	Assistant Engineer (Electrical Protection)	Ensuring all electrical protection equipment is frequently checked and functions correctly.	Checking protection equipment in accordance with a planned programme. Tests are on 11KV; 3.2 KV and 415 V. Carrying out technical investigations into electrical problems on the plant and protection equipment. Investigating any electrical incidence. Keeping aware of current technical developments on the subject. Work has a high routine content but needs a reasonable approach. Tends to be a solo job.	25		43	90	0	10	12	15	67	30
M16	2	Assistant Engineer (L. E. & I. Long Term)	Overall to maintain Light Electrical & Instrument equipment at maximum availability and efficiency commensurate with economic advantage. To assist in the preparations for major outages.	Reviewing existing routine maintenance procedures and recommending changes from past experience. Some technical involvement with maintenance work in process and reporting on progress. Preparations for major outages as a member of the Project Team and arranging for installation of any new instrumentation. Supervision of any new work and contracts; acquisition of spares and re-cataloging of spares for instrument work. Work associated with the installation of new control systems. Keeping drawings and manuals up to date as they relate to changes on the plant. Being aware of technical improvements in the field as they might apply to the Industry. Much more time on plant, given semi - clerical support tasks.	60	13	44	58	7	9	41	25	12	78
M17	2	Assistant Engineer (L. E. & I. Short Term)	Maintenance of Light Electrical and Instrument plant at maximum availability and efficiency commensurate with economic advantage. Technical assistance to the short term work in progress.	From existing routines and experience establish changes (when appropriate) in the frequency and content of future maintenance. Maintaining technical involvement in routine defect and preventative maintenance work with a view to improvements when appropriate. Designing and seeing through short term modifications to achieve minor improvements. Some involvement in the long term projects as a member of the Project Team. Recataloging spares which relate to instrumentation. Carrying out work relating to the boiler and turbine automatic control systems being installed. Keeping all drawings and manuals relating to the plant updated. Day to day routine supervision of maintenance work in progress; giving technical advice to the Foremen and craftsmen. Being aware of technical improvements and relating them to the plant at the location. Much of work could be classed as technical administration.	60		42	64	4	18	25	45	13	53

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
M18/ 22	2	Assistant Shift Engineers (Inst. & Control)	To provide technical supervision and advice in the relevant field on a 24 hour basis.	Co-ordinating instrument work on plant with the needs of the operating staff. Organising the necessary supplies, and dealing with industrial relations aspects in relation to the maintenance staff. Carrying out technical investigations on the plant; providing technical advice and work supervision; dealing with queries, investigating faults, carrying out tests. Occasional day work dealing with long term requirements in the electrical and instrument fields for a particular area of the plant. Close working grouping with other shift maintenance engineer and with operations engineers.	10	6	41	58	10	20	19	82	15	10
M23	2	Assistant Engineer (Defects and Contracts)	Monitoring maintenance contracts (mechanical and H.E.) to ensure correct standards of quality and programme adherenace. Investigating recurring faults, recommending corrective action.	Frequent inspections of maintenance contracts when in progress. The time fluctuates with the period of the year. Final inspections of completed work. Writing contract specifications; organising preparation of drawings, dealing with R.H.Q. Checking pre-contract progress to ensure that the work will start on time at location. Investigating alternative sources for equipment; following up urgent orders to maintain programme dates. Investigating recurring defects. When such defects are major, work is handed over to Development. The work involves inspecting items when dismantled, carrying out simple checks, taking measurements etc.	90		40	54	0	10	41	48	35	22
M24	2	Assistant Engineer (Special Services and Welding)	To ensure that all welds and welding work on the location are engineered to the highest standards of current technology.	Organising and monitoring N.D.T. inspections to plant and carrying out some such testing in person. Maintaining close contacts with N.D.T. organisations to ensure that the best methods are being used. Preparing and N.D.T. testing programme; subsequently organising facilities. Obtaining outside advice on the problems, organising appropriate courses of action, arranging for work to be carried out by station staff. Monitoring the quality of welding work on site, inspecting completed work. Conducting tests associated with the recruitment of welders and subsequent testing of welders. Advising on the training requirements for welders, building-up a bank of knowledge of welding contractors.		25	38	24	6	18	53	17	28	56
M25	2	Station Warden	To maintain security, fire fighting and building maintenance systems at the location. To administer the storage areas and maintain the grounds and cleaning services.	Daily checking of security; less frequent checking of fire fighting equipment and systems. Organising training programmes for Industrial staff, and competitions for fire fighting. Preparing work programme for the building maintenance, having discussions with R.H.Q. for [illegible] Checking work relating to contracts, monitoring the cleaning of buildings, roads and grounds. Dealing with the maintenance of the vehicles on site. Administration of the industrial area, reading the meters for the tenants; organising visits to the nature reserve. Dealing with problems arising from the public road and general administrative matters. Tends to be a combination of 2 jobs and a mainly solo role.	25	40	57	33	4	20	92	70	43	36

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
M26	2	Assistant Engineer (M. & H.E. Long Term Programming)	To ensure that the preparatory work for a major outage is efficiently carried out.	Investigating tasks expected to be required during major outage and carrying out the detail work, such as tools, access, manning and storage needs. Analysing each of the separate jobs in a major outage and assessing the auxiliary requirements such as availability of other parts of the plant. Organising the supply of special equipment such as lifting gear, scaffolding etc, and preparing these requirements as a work programme. Maintaining close contact with the Overhaul Project Team and discussing the needs of the remainder of the Maintenance Department. On completion of a major outage, assessing the effectiveness of the programme the modifying the subsequent programmes accordingly. Ensuring that information relating to overhauls is filed by the Planning Department. Essentially a co-ordinating and planning job of limited duration.	50	100	39	41	2	0	62	0	24	81
M30/ 31	2	Relief Shift Maintenance Engineers	Providing continuous cover for the technical supervision of shift maintenance work and carrying out various other tasks when not on shift within the Maintenance Department.	Co-ordinating instrument maintenance work with the operational requirements. Organising supplies of spares and materials and checking the work of contractors. Maintaining good industrial relations and dealing with some NJIC problems. Carrying out investigations on the plant. The post holder carries out technical investigations, supervises work and checks the equipment prior to re-commissioning. Modifying work procedures and raising requisitions when required. Background technical reading relating to the work. Carrying out long term investigations into specific items of plant as an infill job. Spend most of time on shift duties.	10	16	39	48	2	26	27	48	38	17
M32	2	Relief Shift Maintenance Engineer	When on shift to provide a continuous technical supervision and service in the maintenance field for the operation of plant. To ensure that new instrumentation on the plant is effectively installed. To seek satisfactory alternatives for obsolescent items of equipment.	1/5th time on shift; co-ordinating maintenance work with operational requirements, organising supplies of spares, on site investigations of plant, supervising work, testing plant before recommissioning. 4/5th time on days; investigating special projects, e.g. additional instrumentation. The post holder discusses requirements, acts as Technical Officer, organises equipment, monitors installation, programmes work, writes contracts, and checks on completion. Finding alternative suppliers for existing equipment when declared obsolescent, determining future needs. Preparing recommended spares lists for instruments. Acquiring knowledge of auto-control systems by background reading, etc. Spends most of time on day work dealing with future provision of equipment ie tech. admin.	80	16	43	46	5	15	47	19	31	63

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
M34	3	Assistant Engineer (Inst. & L.E. Long Term)	Assist in ensuring the Maintenance Department's effectiveness by preparing recommended spares lists, and much of the preparatory work in advance of major outages. Also carrying out checks on inter-locks and sequences.	Preparing recommended spares lists and determining stock-holding levels. Preparing spares requirements prior to major outages. Working on the detail planning of tasks during a major outages. Carrying out inter-lock and sequence checks after outages and prior to re-commissioning. Detailing plant modifications and arranging for appropriate supplies or for contracts for such work. General background reading relating to the subject. Much of work is technical administration.	50	50	46	55	0	5	60	20	15	85
M35	Eng. Asst.	General Assistant (L.E. & I.)	To assist in the maintenance of light electrical and instrument plant availability and to assist in carrying through improvements.	Carrying out various tasks to assist in the long term maintenance, e.g. taking readings of the plant, checking completed installations or checking instrumentation after major overhauls. Also looking into the expressed requirements or the effects of incidence relating to the plant and making recommendations to avoid recurrence. Such recommendations may involve additional instrumentation, in which case recommendations are followed up and the post holder will be involved in the installation of such equipment and testing the completed system. Assisting in the work relating to major overhauls. Most work tends to be of the short term project type.	80		38	80	0	10	10	10	10	80
M36	3	Engineering Assistant (Electrical Equipment)	To assist the Engineer (Electrical Protection) to achieve the objectives, namely, that all electrical protection and associated equipment is checked and functions correctly.	Checking electrical protection equipment in accordance with the planned programme. Such checks are subsequently recorded. Routine checking of AVR's on the four turbo-alternators. This is two man job. Carrying out technical investigations into electrical problems on the plant and equipment. Such investigations would involve checking on data in books, contacting suppliers, Headquarters, etc, and planning reinstatement work. Monitoring work in progress on re-instatement of plant and testing before returning to service. Carrying out insulation measurements on stators. Carrying out similar insulation tests on large motors and cables. Keeping up to date of technical developments in the field by background reading and some training. Routine checking tasks should be part of electrical protection job.	20	10	41	74	0	15	21	13	60	37

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
01	P	Operations Superintendent	Organise and manage the Operational Department to ensure the plant is operated in accordance with System requirements. Also that plant operates at a maximum efficiency and availability commensurate with economic advantage. To contribute towards resolving station problems as a member of the Management Team.	Attending daily, weekly and monthly meetings of the Management Team, dealing with short term and long term station problems and policy formulation. Attending meetings e.g. budgets, Works Committee and LAC's. Maintaining informal contacts with senior members of Management. Frequent discussions with Shift Charge Engineers and other members of the Department to pass on information, make decisions and monitor progress of work. Thinking through requirements and technical problems, making decisions etc. Administrative matters, permits to work etc and correspondence. Monitoring staff training. Interviewing new staff and Technical matters including requests from RHQ, manufacturers, other power stations etc, also technical discussions with Departmental and Station staff. Organising spares and services; giving technical advice to engineers on site and work progress information. Discussions with System Operations about System requirements and reporting plant state. Discussions with the Coal and Ash Engineer and the Station Chemist. Stand-by duties for other senior staff members when they are on leave. Background engineering reading. Dealing with technical and public relations visits. Handling human relations and personal problems of staff. Monitoring the general state of the plant. Member of management team. Maintains close links with shift teams.		21	50	47	28	9	47	44	42	45
02	S	Station Chemist	To monitor conditions on plant by chemical checks. To provide support services, such as photography, metallurgy etc. To check and control materials coming on to site, e.g. coal.	Attending various Management Meetings, some concerned with policy, some concerned with short term co-ordination. Discussing aspects of new plant with Project Group representatives; attending meetings with representative bodies, e.g. Alkali Inspectorate, Water Board, etc. Discussing problems and needs with other engineers at site. Monitoring and discussing technical matters with the Section staff and dealing with industrial relations. Carrying out specific technical investigation arising from new legislation or special technical problems relating to the plant. Preparing various reports and writing work specifications for staff members. Remaining aware of technical development in the Chemistry field. Works closely with assistant Chemist and Oes Superintendent. Frequent direct contact with Station Manager.	30	15	46	51	20	6	45	35	47	40

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
03/7	Sen.	Shift Charge Engineers	To operate the plant in accordance with daily work programme and as regulated by System Operations. To achieve maximum efficiency commensurate with plant security and availability. To exercise judgement and take appropriate actions to ensure the safety of plant and personnel.	Attending meetings during the day when appropriate and having discussions with the Operations Superintendent. Organising resources and having contacts with day staff. Passing on information to next shift. Discussions with the Shift Maintenance Engineers to co-ordinate their work with the needs of operations. Issuing and cancelling permits to work which sometimes require physical checking on the plant. Supervising the work on the plant, investigating faults and discussing the work with the Foremen. Supervising the Shift staff in general, dealing with industrial relations and personal problems. Carrying out routine administrative work such as ordering consumable materials. Carrying out various progress checks on the staff's work. Preparing a Station Log and writing reports on special incidents or tasks. Carrying out special investigations which are sometimes given to individuals. Dealing with any queries and complaints from the public. Carrying out isloations to Grid requirements. Handling total responsibility for stations outside normal hours. Taking appropriate action in event of emergency.		19	42	24	26	31	29	70	32	8
010	1E	Assistant Station Chemist	To assist in the management of the Chemistry Section and the work of the Section, i.e. monitor chemical conditions; control of materials and emissions; certain services.	Monitoring Laboratory Staff Work, carrying out checks and assisting when work load is high. Performing analyses when anomalous results occur. Checking chemical stocks, re-ordering supplies. Making various weekly and monthly returns. Talking through problems relating to the Chemical plant and acting as Deputy for the Station Chemist.		5	39	47	12	20	24	39	46	18
011/15	1E	Assistant A.S.C. Engineer (Control)	Assisting plant operation according to daily work programme. To achieve maximum efficiency commensurate with security. Monitoring plant in the short term to take immediate action in the event of specific events occuring.	Ensuring resources are available and progressing maintenance and Works Office procedures so as to co-ordinate the work with the operational requirements. Dealing with outside enquiries usually by telephone. Handing over to the next shift. Discussing maintenance work with the shift staff and keeping contacts with the Coal and Ash Shift Staff. Maintaining good industrial relations with the shift staff and sometimes dealing with personal problems. Making various statutory returns. Preparing the station log. Writing reports on the specific incidents or tasks. Being instantly available to make decisions relating to the operation of the plant and continuously monitoring that operation. The purpose is to maintain as near as possible optimum conditions. Regulating output in accordance with System Operation requirements. Remote switching in the Sub Station. Job rotated with other ASC.		6	40	37	7	29	35	84	24	0

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
017/22	1E	A.S.C. Engineer (Plant)	To assist in plant operation in accordance with daily working programme so as to achieve maximum efficiency commensurate with plant needs. To ensure all work on the plant is optimised to maximum availability commensureate with efficiency.	Checking that the Maintanance Department is carrying out the programme of work to ensure plant availability as arranged. Handing over to the next shift; having discussions during the shift on technical progress with the Maintenance Engineer and other staff to ensure that work is progressing satisfactorily. Issuing and cancelling permits to work by investigating and considering the effects on the plant. (Physical checks are frequently carried out). Supervising the plant and Operating Staff; investigating faults and discussing work problems, taking measurements for test conditions and recommissioning. Dealing with Shift Staff, maintaining good industrial relations, writing reports on specific incidents or tasks, discussing sundry problems with the Shift Team. Carrying out Sub Station isolations when required. Job rotated with other ASC about half the time spent on permits to work.		6	39	51	0	27	25	53	46	4
027	1E	Coal and Ash Engineer	To ensure that coal stocks are maintained and available in the bunkers when required and Ash Disposal is efficient and economic and ensures uninterrupted operation of the plant.	Frequent checks on fuel allocations and deliveries with Headquarters and British Rail and N.C.B. Deciding on allocation of particular consignments and planning the day's work with the Foremen. Carrying out routine checks of plant and stocks and monitoring the progress of the programmed work. Issuing permits to work for the Plant, usually also checking before issuing. Planning the maintenance work for the plant and thinking through problems and discussing improvements. Checking the records of stock to ensure that consignments are correct. Managing the Ash Plant, organising maintenance and checking operation is satisfactory. Discussing disposal with the Contractors and planning and organising the new disposal plant. Ordering fuel oil weekly; dealing with general routine matters. Dealing with industrial relations and staff problems when they arise; discussing all plant aspects with the Operations Superintendent. Delegation to Foremen practiced.	15	18	56	49	21	27	51	65	51	32
030	2E	Assist Chemist (Plant)	Ensure Chemical Plant is operated effectively.	Monitoring and examining the operation of the chemical plant. Dealing with problems, making sure that materials and labour are available and work is progressing when necessary. Supervising coal sampling and ensuring the plant is [illegible] random checks on the coal samples from sampling to analysis. Writing work specifications for industrial staff. Part of chemistry laboratory team. Job changed regularly.		5	38	31	5	37	27	40	38	22

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
031	2E	Assistant Chemist (Analyses)	To carry out the more complex analyses on various substances	Carrying out the complex aspects of water analysis, such as trace metals. Investigating various deposits by carrying out routine chemical analyses. Chromatographic analyses of water and gas, and certain routine special analyses. Member of chemistry team. Job rotated monthly.			38	90	0	0	10	30	40	30
032/36	2E	Assist Engineer (Operations)	To assist in operating the plant in accordance with System Operations and the maximum efficiency commensurate with security, availability etc., by ensuring that work on plant is carried out in accordance with the plant programme.	Handing over to the next shift. Discussions during shift with the Maintenance Engineers and other maintenance staff Issuing and cancelling permits to work by investigating the effects of the requests, carrying out tests and physically checking the state of the plant. Supervising plant and plant operating staff. Investigating faults, discussing work with Operations Foremen, taking measurements and carrying out checks. Maintaining good industrial relations with the shift staff. Permit issues occupy nearly half the time of this post.			39	42	0	37	25	61	38	5
040/44	2E	Relief Engineers	On Shift: Same as Assistant Engineer (Operations). When not on shift: Carrying out specific investigations on it items of plant to improve overall performance.	On Shift: (50%) Discussions with Shift Maintenance Engineers and other Staff. Issuing and cancelling permits to work after various investigations and checks before reinstatement of plant. General supervision of the plant and the operating staff. Investigating and carrying out tests. Maintaining good industrial relations with the shift staff. When on Days: (50%) Carrying through various projects, particularly investigating a problem relating to the plant, proposing a solution, initiating the work and monitoring progress. Also subsequently writing reports, e.g. investigation of the fuel oil system.	40		39	61	0	20	23	32	39	33
050	3E	Assistant Chemist	Carrying out various analyses to support the Chemistry Section's objectives of monitoring plant conditions and controlling materials onto site and ensuring emissions, etc. are within the requirements.	Monitoring the analysis of the water by the General Chemists by carrying out frequent checks on results and analysing anomalous ones. Re-checking any variations from accepted values. Checking atmospheric pollution in analyses which are carried out by A.P.A.'s. Ensuring the conditions are in accordance with the laid down system and re-checking any unusual results. Carrying out photographic duties on site, usually technical. Works as a Member of a Team.			39	47	0	30	23	70	30	0

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
055	EA	General Assistant Chemist (Coal Analysis)	To assist the Chemistry Department achieve its objectives by monitoring the coal supplies.	Coal analyses. Carrying out a series of con-current tests for monitoring coal quality. These include taking samples, weighing and carrying out a series of chemical analyses on the reduced sample. Also checking proximate analyses which are carried out by the A.P.A.'s. Any anomalies are investigated. Maintaining the coal records. Routine job			39	55	0	10	35	70	30	0
056	EA	General Assistant Chemist (Water Analyses)	To assist the Chemistry Dept. achieve its overall objectives by a series of water analyses.	Analysing various water samples from different areas of plant. The mineral and other contents are carefully measured quantitatively by a successive series of analyses on a daily basis. Routine job and member of team.			39	90	0	0	10	90	10	0

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T1	P	Techanical Development Engineer.	Complete new plant commissioning; plan and organise Development work to improve plant availability reliability and efficiency economically. To provide efficiency, testing and planning functions.	Attending Station Management Meetings and daily Co-ordination Meetings. Chairing various Working parties usually technical. Dealing with administrative matters and industrial relations and budgetary requirements. Directly carrying out technical investigations with follow up preparation of contracts and the implementation of schemes. Investigating special problems, usually at short notice. Providing technical guidance and decision making for the Department. Background reading and courses in the appropriate technical field. Member of Station Management Team and Leader of Departmental Management Team.	70	12	52	60	40	8	29	26	55	56
T2	Sen.	Commissioning and Development Engineer	To ensure successful commissuoning of new plant; to manage a programme of development wo k designed to improve relaibility availability and efficiency.	Co-ordinating Section activities with the Station requirements by attending various meetings daily, weekly and monthly. Producing Station information sheets. Dealing with some public relations aspects and general administrative matters. Monitoring apprentice training. Maintaining contacts with other locations, especially scientific ones. Monitoring progress of work by Sub-Sections and giving technical advice and decision making. Dealing with the certification and documentation of new plants and monitoring contracts. Thinking through new problems and allocating the work within the Section.	90	20	42	32	15	18	46	43	45	23
T3	Sen.	Planning Engineer	To manage the Planning Department which allocates manpower and other resources in the short and long term so as to match the routine and defect needs of the plant.	Checking the daily state, adjusting priorities if required. Attending morning meetings, progressing work and distribute action sheets for senior staff. Discussions with works office and Planning Engineers regarding priorities. Various administrative matters and maintaining good industrial relations, dealing with personal problems. Monitoring progress of work, discussing policy and technical problems. Attending various meetings on and off site. Discussing problems with senior engineers on site. Thinking out and implementing new procedures and policy. Discussing the following day's programme of work with the Planning Engineers. Checking P & P returns, preparing training programmes. Preparation of planning networks, permits to work procedures and monitoring similar work by the Assistant Planning Engineer. Preparation of Station Plan, holding technical discussions with outside bodies. Preparation of monthly analyses for maintenance. Attending monthly Meetings to determine policy. Dealing with telephone enquiries, reading reports and generally keeping up to date with technical aspects of the work. Managing and dealing with the administrative aspects of the Project Team. Member of several groups.	10	50	58	56	24	15	58	59	52	42

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T4	Sen.	Efficiency and Testing Engineer	To provide a monitoring service for the plant at the location and the station performance in relation to the plant. To provide management information statistics and various measurements on the plant.	Attending daily meetings and special ones when required. Visiting plant, monitoring progress of work by the Section, maintaining good industrial relations. Dealing with administrative aspects of the work, sending out statistical information into other Departments. Checking the weekly results including critical stock levels and ensuring that the run out times are properly calculated. Monitoring monthly statistics and analysing. These are presented in the form of a report. Analysing statistics and graphs produced by members of the staff. Progressing work in the station daily. Discussions with technical visitors from firms, RHQ., etc. and for public relations purposes. Dealing with telephone enquiries from various quarters, attending meetings at other locations. Discussing problems relating to the Section's work and giving advice and decisions. Preparing reports, planning and organising a work programme; investigating new equipment for the Section. Maintaining an awareness of current technical developments in the field. Leader of statistical analysis group.	10	15	56,	66	16	15	49	37	71	38
T6	1	Assistant Development Engineer	Investigation of problem areas to discover and implement suitable solutions.	Monitoring plant performance in the longer term and assessing the relevance of the data obtained. Deciding on course of action arising from investigations. From the course of action development of project by seeking suitable solutions to the problems. This involves discussions with manufacturers, S.S.D., etc. and Project Liaison. Subsequently progressing schemes. Producing specifications and arrangements for placing contracts. Subsequent discussions with contractors. Monitoring contracts in progress and checking work on completion. Assisting the Section Head with administration aspects of work and in the production of information sheets. Setting tasks and projects for Apprentice training. Also doing some teaching.	90	15	39	34	12	16	40	30	40	32
T8	1	Assistant Planning Engineer (Work (Work Study)	To ensure that as much of the NJIC work is measured under the P & P Scheme as possible. To work towards optimum methods on the plant so as to maximise availability.	Planning and organising Work Study Assistants' duties and giving guidance on problems arising. Dealing with queries about times and making decisions. Carrying out quality control checks on timing of cards. Checking that all documents are completed on time and that performance figures and managerial indices conform to Regional standards. Maintaining a liaison with other departments to ensure that manpower requirements and work organisation are met. Dealing with administrative matters, attending to training requirements. Discussing Work Study and Method Study problems with the Planning Engineer. ... Continued		100	41	41	3	15	50	39	58	12

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T8	1	Assistant Planning Engineer (Work Study) (Continued)		Determining relative priorities for work. Establishing method study procedures. Carrying out more complex ones personally and discussing with the Planning Engineer and the Section Heads the findings. Preparing reports and following up on method study and checking that recommendations comply with statutory and other requirements. Organising information systems, ordering any equipment and dealing with general enquiries. Standing in for the Short Term Planning Engineer and carrying out background reading. Close team work with Short Term Planning Engineer.										
T9	1	Assistant Planning Engineer (Short Term)	Organise and supervise short term planning to optimise work force effectiveness and plant availability.	Checking overnight logs, discussing changing aspects and monitoring progress of work. Discussing priorities with senior staff and, after re-arranging, alter the work schedules for the W.S.A.'s. Discussing plant progress and outstanding permits to work with engineers in Operations and Maintenance. Preparing jobs and Work programme lists before units come off. Preparing a daily Priority list for the following day. Monitoring the work of schedul ng to ensure that waiting time, wasted effort, etc. is minimised. Preparing reports on progress with important jobs and discussing these with the Planning Engineer. Attending meetings where information is required and dealing with general enquiries. Carrying out background reading, checking planning procedures, proposing any improvements. Monitoring the plant history system. Carrying out general administrative duties and giving guidance to Works Office Staff. Working closely with Work Study Engineer.		100	43	36	3	24	49	69	25	18
T10	1	Assistant Planning Engineer (Long Term)	Supervision and direction of long term planning to monitor and programme Station work for next three years.	Discussion with the Planning and other senior engineers regarding work lists and with suppliers and contractors relating to their work. Production of networks, discussion with Maintenance engineers on timings, analysing resources required and production working programmes. Computer analysis of complex parts of the programme and formulating a total work schedule with job cards for all shut downs. Co-ordinating production of work specifications and spares requirements from work schedules and establishing Project Office for controlling major shut downs. Instituting weekly checks and control systems. Modifying work schedules produced for previous outages and recording systems sequences of work, spares, etc. for future use. Holding discussions with the Section Head on progress and with other Group Members. Planning new policies and procedures or varying existing ones. Production of total maintenance plans from discussions with engineers. Transferring systems to the computer.	20	100	48	55	6	12	52	10	48	67

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T11	1	Assistant Efficiency Engineer	To provide a plant measuring service for other departments and an efficiency monitoring and control service. To provide statistics and management economics services for station performance monitoring.	Visiting plant to monitor the work in progress and to assess new problems. Re-ordering routine supplies, dealing with telephone enquiries from other engineers and other locations. Technical discussions with companies, R.H.Q. Project Groups, etc. Reporting to the Section Head and discussing projects. Analysing data obtained from the plant and occasionally directly checking results. Dealing with short term testing as needs and emergencies arise, working on major projects including preparation of schemes and progressing of these and finally presenting results. Analysing the section's needs in terms of manpower and equipment and dealing with training requirements and keeping generally informed of technical developments.	30	20	50	75	0	10	47	38	35	59
T21/ 22	2	Assistant Engineer (Planning - Short Term)	Ensuring that site work is planned to optimise efficiency and effectiveness with maximum availability.	Half the duties relate to 24 hour scheduling and are:- Scheduling daily maintenance work within Works Office priorities. Discussing the next 24 hour work programme with Engineers and Supervisors, making variations when appropriate. Writing the programme, monitoring work in progress with Engineers and ensuring that priority work commences as planned an monitoring any delays. Checking the programmed work to ensure that no wasted effort is included due to interference. Maintaining contact with Operations to ensure access to plant and to ensure no plant operation difficulties. The remaining tasks are for medium term planning. Scheduling maintenance work for the next three days, i.e. roughly allocating work to meet plant requirements and absorb craft availabilities. Adding to provisional programme requests for defect work and automatic preventative maintenance. Ensuring that the plant will be available and including sufficient back-up work to cover eventualities, if materials or plant become unavailable. Scheduling weekly routine, noting any work which will require loss of generation. Dealing with queries from engineers and others. Background reading and attending courses for training. Jobs overlap to provide 7 day cover.		100	41	32	0	4	71	80	21	6
T23	2	Assistant Engr. (Planning)	To collate relevant data to produce and monitor station work plans and programmes for the past three years	Discussions with Planning and senior engineers to prepare work lists. Production of networks from timings for various parts of the work and reference to previous networks. Analysing resources for various programme stages to produce an effective working programme. Analysing by computer the more complex parts. Producing a work schedule from the related job cards. Establishing a Project Office for major shut-downs to monitor progress and maintain weekly plans and controls. Attending progress meetings with contractors. Establishing scheduling systems for normal work to be slotted in. Recording other information from previous overhauls for future use. Discussions with Section Head and senior engineers on progress, programmes and other matters. Planning new policies and procedures.	30	100	44	63	0	10	43	5	45	66

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T24	2	Assistant Engineer (Efficiency)	To provide technical services at the location in the form of plant measurements and efficiency monitoring and control. To assist in the provision of statistics and management economics information for station performance measurement.	Dealing with special projects & tasks, e.g. RHQ computer link; arranging programmes & other technical aspects with RHQ staff. Assisting in short term tests and efficiency work, e.g. checking plant operation relating to shortfalls etc. Theoretical investigations into special problems especially those involving the computer software. They may be technical or managerial economics based. Attending training and educational courses, much in the postholder's own time. Dealing with telephone queries from enquiries on and off location relating to computer analyses.	60	10	51	86	0	15	32	33	25	75
T25	2	Assistant Engineer (Efficiency - Turbines)	To provide a turbine plant measurement service at the location and efficiency monitoring. Also servicing the management economics and statistics area.	Maintaining contact with other outside groups so that experience gained at other locations is available. Answering queries from outside groups and other power stations. Investigating anomolous plant performance; taking measurements, carrying out tests and analysing data from station manuals and other sources. When a problem is identified it is passed on for solution to the Commissioning and Development Section. Dealing with short term problems and emergencies. Usually due to short-falls in plant operation, arranging for measurements to be taken and preparing results and reports. Supervising the testing and efficiency work of the Assistant Engineers. Discussing the results of analyses and assisting with calculations and problems. General background reading and training.	50		41	67	5	15	21	38	30	40
T26	2	Assistant Engineer (Planning and Works Study)	Monitoring important parameters relating to the work programme and the P & P Scheme results.	Checking P & P Scheme Work, sample checks are carried out to ensure the system is being operated correctly. Assisting in checking scheme results; giving guidance to W.S.A.'s on problems relating to measured work, emergency work, etc. Standing in for the Works Study Engineer when absent. Monitoring the work control systems, suggesting improvements. Control of plant running and maintenance work. Correcting data on hours run, updating display panels and initiating the maintenance programmes. Monitoring the scaffolding hire system. Reporting daily to Grid Control in the absence of the Assistant Planning Engineer. Carrying out various tasks relating to the collection of data. Background reading of technical journals and training systems.		100	40	16	3	28	57	40	42	22

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T28	2	Training Engineer	To ensure that all staff at the location receive appropriate training.	Preparing annual lists of persons suitable for various courses and building up the annual training programme. Obtaining clearance from Departmental Heads, etc and arranging for the budgetary provision. Clearing final programme with R.H.Q. and matching names to allocated places. Discussing the course content and purpose with nominees and dealing with any problems arising, Organising on site training courses, these tend to be practical. Arranging for lecturers, participants, accommodation and other administrative matters. Preparation of course material for lectures, sometimes including notes. Giving lectures; dealing with apprentices and trainees. Monitoring the performance of Apprentices. Implementing the E.S.I.T.B. Recommendations, namely, preparing training guides. Assessing the training programme in progress and producing information sheets. Interviewing applicants for Apprentice training; acting as administrator of the Board's Correspondence Schemes. General Background reading.	10	33	42	35	5	12	59	15	26	70
T30/ 37	3	Assistant Engineers (Development)	To assist the Technical Development Department in achieving its objectives of 88% availability and efficiency and reliability at a maximum by 1977. The post holder's objectives are to investigate problemsareas, seek solutions and implement them.	Working on items of plant yet to be commissioned; taking measurements, monitoring work, communications with Project Group, manufacturers, etc. Monitoring plant labelling and ensuring defect work is carried out in accordance with certificates. Joining annual summer overhaul teams by carrying out work such as checking plant, taking measurements, etc. Deciding on appropriate courses of action, carrying out tests to endorse that action and developing and progressing projects arising. Discussing with Senior Engineers the nature of problems, and, in the case of smaller tasks, implementing those decisions and monitoring the work. Similarly, dealing with problems on the Dust and Ash and Coal Plant.	100		39	74	2	5	20	33	45	23
T38	3	Draughtsman	To provide Drawing Office services at the location including modifying and updating drawings and providing copies. Also providing a design service at the location. Issuing permits for excavations on the site.	Providing permits to excavate on site. This involves initial investigation with drawings and at the location and ensuring that subsequent excavations do not deviate from the indicated areas. Also checking that services on site are properly identified on the site drawings. Provide a design and drawing service for the plant and detail modifications, e.g. measurements on the plant and subsequently preparing drawings and prints for contracts. Copying drawings for site needs. Setting up an indexing system for drawings on the site; examining drawings and modifying to ensure they correspond to the actual plant. Discussing requirements for new drawings with the various engineers. Checking Station Manuals and updating the drawings. General administration of the Drawing Office.	80		39	68	0	0	32	11	65	24

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T39	Eng. Asst.	General Assistant (Short Term Planning)	Assisting Planning Section to achieve its objectives by carrying out tasks to monitor parameters relating to station plant.	Daily reporting to Grid Control on the state of the plant availability. Maintaining lifting appliance inventory. Arranging for inspections and providing replacement equipment. Preparing lists of routine work outstanding in the various categories to enable additional resources to be obtained. Updating visual displays, recording routine maintenance and running hours. Preparing fault reports. Marking up routine print-outs, progressing important work in arrears. Investigating specific defects to determine frequency. Preparing work schedules for short term shut-downs; providing cover for Assistant Engineers (Short Term Planning). Assisting in various aspects of planning at the direction of First Engineers. Background reading and attending courses.	10	37	40	31	0	0	75	46	47	13
T40/ 45	Eng. Asst.	General Assistant Engineers (Development)	By investigating problem areas and implementing solutions to assist the Development Department in achieving 88% plant availability with efficiency and reliability by 1977.	Remaining commissioning work associated with No. 4 Unit. Monitoring running and testing of items and taking a great many readings. Outstanding work in commissioning items relating to the previous Units. Ensuring that defects on new plant are properly completed, including plant labelling. Assisting in the major outage programmes. The team members will take measurements on plant and use the information subsequently. Routine monitoring of operating plant including log reading and checking through recordings. The information is used to investigate the problems and seek solutions. Schemes will be prepared, specifications produced, and, in the case of smaller contracts, the Assistant Engineers may see them through.	100		39	60	0	5	35	43	44	13
T46	Eng. Asst.	Assistant Engineer (Planning)	As a member of the Long Term Planning Team to collate relevant data to produce and monitor station work and programmes for the next three years.	Assisting in preparation of the visual display systems to enable all persons to be informed of progress on major projects. Collation of information for the production of a total maintenance plan. Amendments and additions to the routine maintenance system from information in the current programme.	40	100	39	36	0	0	64	5	29	66
T47	Eng. Asst.	Assistant Engineer (Planning)	To collate long term planning data to assist in production of more effective plans and programmes for Station work for forthcoming years.	Assisting in the production of visual display systems related to major outages. Formulating and producing total work schedules of information flows with relevant job cards. Establishing the routines of a Project Office for major outages. Attending progress meetings for major outages and having discussions with the Group Leader. Setting up a Work Card System so that work schedules are produced from previous modified experience. Editing and updating the inventory system relating to plant item records. Maintaining the Statutory Insurance Records for Pressure Vessels. Keeping the Station Manuals updated.	10	100	39	15	0	77	79	13	39	49

Staff Tree No.	Grade	Descriptive Title	Objectives	Summary of Tasks	Com.	Plan	Working Week	Nature of Tasks (%ages Total Time)				Time Scale (%ages of Total)		
					%	%	Hrs.	Tech.	Man.	Sup.	Adm.	Short	Med.	Long
T48/ 52	Eng. Asst.	Assistant Engineers (Efficiency and Testing)	To provide plant measurements for other departments and for the monitoring and efficiency service. To assist in providing Management statistics.	Receiving instruction and training in the methods of measurement taking on the plant. Routine monitoring and testing on the plant. Taking routine check readings on the plant. Taking experimental tests on items of plant, ffrequently as a member of a team. Carrying out urgent tests when plant breakdowns occur. Making calculations and carrying out basic analyses from the measurements taken. Plotting graphs. Carrying out preventative maintenance tests, such as vibrations, on items of plant. Plotting graph of results. Installing measuring devices such as the Mill Fire Detection.	30		39	92	0	0	8	51	10	39

A few comparisons were possible between this study and the times obtained in the previous study of management teams in power stations carried out about four years beforehand. The working week of the management team members at that time is shown in Table A.2.

Table A .2 - Average Length of Working Week of Departmental Heads During Two Studies

Post	Man.Teams Study 1971 hrs	Job Analyses 1975 hrs
Station Manager	54	58
Deputy Station Superintendent	45	51
Maintenance Superintendent	46	48
Operations Superintendent	47	50
Technical Development Engineer	47	52
Station Administrative Officer	50	46

During the management study the Administrative Officer was engaged in writing station standing orders and considered his normal week was about 45 hours. It is evident that for all the management team the expressed wish at that time for an eventual reduction of the working week following the commissioning of the station has not occurred; in fact it seems to have been significantly lengthened during the post-commissioning period. Some allowance must be made for the fact that the previous study was measured (and any omissions would lead to a reduction in hours) whereas in this study hours were estimated and the tendency might have been to over-estimate a little.

The overall pattern of the extension of the working week for the engineers is given in Table A .3.

Table A .3 - Extension of the Working Week Percentage

Staff	Excess Hours %
Senior Management	34
Maintenance Engineers	14½
Operations Engineers	10
Technical Development Engineers	13½

For the administration staff the only members to significantly exceed the working week were the Section Heads for whom the figure was about 9%. The lower figure for Operations Engineers can be explained by the preponderance of shift work with its common pattern of overlapping shift teams giving about 5% additional hours. The remainder derived from the higher levels for Shift Charge Engineers, the Chemist and the Coal & Ash Engineer. For the Maintenance and Development Engineers the additional work was fairly evenly spread, but with a tendency to be less for junior Engineers.

Returning to the percentages given in Table A .1 for the various types of duty, these have been summarised in Table A .4 for the groups of staff and show a distribution pattern of the type which might be expected.

Table A .4 - Distribution of Time as Percentages Between Functions for Groups of Engineers

Type of Post	Function				Timescale		
	T	M	S	A	S	M	L
Sen. Man.	28	39	13	20	32	35	33
Maint.Engrs.	47	8	15	30	45	24	31
Ops. Engrs.	43	7	24	26	54	34	12
Tech.Dev.	56	3	7	34	35	35	30
Totals (Av)	48	7	15	30	44	32	24

Key to Table A.4

T = Technical duties

M = Managerial duties

S = Supervisory duties

A = Administrative tasks

S = Short term tasks

M = Medium term tasks

L = Long term tasks

The technical development staff are not greatly concerned with man management and senior management are less concerned with technical aspects than the rest of the staff. This was not always the case, as during the previous study the average value of time spent on technical problems by the management team was exactly 40%. It has been said by various people during this research that senior managers (both in Power Stations and Headquarters) will frequently get involved in the technical aspects of a managerial problem. This is presumably a hazard of recruiting senior management almost exclusively from the ranks of senior power station engineers. Other patterns which can be deduced from the individual post figures (in Table A.1) are a progressive reduction in time on management and supervision going down the levels of seniority accompanied by a trend towards either higher levels of technical work, or administration duties. This trend was slightly less pronounced for engineers on shift whose time was generally about half on technical and one-third to one-quarter on administration.

The distribution of time on short, medium and long term tasks again reflects the trends which might have been expected. Operations Engineers are mostly concerned with immediate (short term) problems as the work pattern is to hand problems on to the following shift. A similar situation exists for the Maintenance Engineers who deal with the day to day problems. At this location, technical problem solving in maintenance is allocated to "long term" engineers whose work patterns are significantly different from the "short term" engineers. The uniform allocation of time between long, medium and short term aspects of work for Management and Development Engineers is interesting and might not imply an even distribution of problems so much as a tendency to reach quicker decisions on short term problems. This might be due to the problems having already been handled at a lower level of management with only senior authorisation being required. In the previous study the number of interruptions was measured at about 16 per day which lends some support to this idea of quick answers or approval being required for problems already analysed.

Picking out some of the major items of interest from the job descriptions, it is evident that formal work groupings occur at several levels in the organization and at the senior staff levels (Section Head and above) it is common for an individual to belong to two groups. The only C.E.G.B. group which is essentially outside the Station is the R.H.Q. Sub-group of Power Stations for which a Group Manager is responsible. On the Station the only member of this group is the Station Manager. One point noticed was the substantial level of time spent on procuring equipment. This is in the region of 10% to 15% for both senior staff and junior engineers, but a peak exists at Assistant Section Head level where between a quarter and a third of time is spent "chasing" suppliers. Another associated task for many engineers is the supervision of contracts and contractors. This involves preparation of specifications and other semi-administrative tasks after the technical decisions have been made. Estimates of the time spent on commissioning work and in planning routines by the engineers are shown in two columns in Table A.1. The totals are equivalent to 30 engineers full time on post-commissioning and development work and 21 engineers on planning duties. It is difficult to be precise about these figures because much of the normal maintenance work might contain elements relating to difficulties with unsatisfactory plant, rather than being entirely due to "fair wear and tear" which is what routine maintenance should be all about. Some evidence for this was obtained at the location from defect analyses which indicate that many plant items were gradually settling down to a steady defect rate (bottom op the so-called 'bath tub' graph). Most engineers include a certain amount of planning in their normal procedures and the figures identified relate to planning procedures and systems, rather than this personal organizing of work. Thus, both figures could be regarded as a minimum and represent 28% of the Station's engineering efforts spent on plant commissioning problems and 20% spent on planning procedures.

Some general outlines of the working patterns were given by some of the Departmental Managers. The Test & Efficiency Engineers each have plant areas which they cover, or have responsibility for a test procedure. At other times they form groups for carrying out joint test programmes. The less interesting jobs are changed on a monthly basis and other posts are changed yearly. Working groups exist across the departmental boundaries e.g. the daily planning meeting and give rise to group loyalty and social links.

Similar specialisation in plant areas occurs for the Maintenance Engineers. On Operations, the two Assistant Shift Charge Engineers change their jobs frequently and the Assistant Shift Charge Engineer (Control) generally monitors overall plant performance, but using different parameters to those of the Unit Operators. He also discusses requirements with the Grid Control Engineers. The Assistant Shift Charge Engineer (Plant) handles about ten permits per day and deals with plant problems usually working in close association with the Shift Maintenance Engineers. Most Engineers on shift have a continuing responsibility task as well as normal shift duties. For example, one Shift Charge Engineer was responsible for governors and investigated in greater depth the less than satisfactory operation of these items.

The overall picture at the Station during the study was of an engineering staff under considerable pressure and not being able to see an end to the situation. However, the Station Manager considered the post-commissioning phase was now ending and it would be followed by a continuing pressure to raise the reliability and performance of the plant. This phase was also to include plant improvements excluded during construction. It should be noted that this particular Station was built with far fewer refinements than others in the 2,000 M.W. programme, partly because it was planned to burn coal (a more expensive fuel at that time) a factor which has now rebounded on the planners.

The Administrative Staff

Their tasks are briefly outlined in Table A.5. The Department is divided into four main Sections covering Stores, Finance, Personnel and Technical Services. The Restaurant is managed by the Department which also provides such services as a Telephonist, Typing, etc. Only one of these Sections (Stores) provided a physical service for the Station and the other three provided information transfer and monitoring functions. It was noticed that each Section was very self-contained with a strong group loyalty. However, staff did sometimes transfer between Sections, more particularly the junior members.

Most of the posts for new entrants contained a high proportion of the routine unskilled tasks, together with certain duties such as filing, which enabled the new entrant to become familiar with the organization. Staff turnover levels were such as to normally ensure an average of only six to nine months in those posts. An assessment

2000MW COAL FIRED POWER STATION - ADMINISTRATION POSTS

TABLE A.5

SUMMARY OF JOB DESCRIPTIONS

STAFF TREE NO	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS
A.1	P7	Station Administrative Officer	To provide effective and efficient administrative services contributing to the overall efficiency of the station.	Review and modify departmental procedures and systems, investigating complaints or failures, discussing these and departmental policy with Section Heads. These tasks occupy 37% of time. Preparation of departmental long and short term plans and monitoring performance against them. Checking Staff absences, leave etc. and organising cover. Predicting future workload, staff requirements and accommodation. Preparing and monitoring departmental budgets. These tasks occupy 13% of time. Interviewing for new staff, assessing staff and providing training and experience programmes. Maintaining good human relation dealing with personal problems. Applying disciplinary procedures when required. Participating in staff training schemes. This group occupied 12% of time. Discussing station policy as management team member; dealing with a specific problem with management team members. Coordinating other departments budgets. Total about 9%. Dealing with any legal or insurance problems; insuring that statutory Acts are interpreted, disseminated and applied as appropriate on the station. 5% of time. Advising middle and senior management on personnel matters especially administration. Providing policy guidance for the restaurant and monitoring its performance. 8% of time. Providing a general service which include the clocking system, office audits, communication systems. Dealing with some public relations function and arranging meetings etc. 7% of time. Sample checking of invoices, checking cash handling systems, checking productivity scheme returns for administration NJIC staff, dealing with non routine administration matters. Maintaining contacts with R.H.Q. and other locations and being aware of current administrative procedures. The last group total 22%. The post holder is a member of the station management team and also the leader of the administration management team. In addition, close contacts with administration staff are maintained.
A.2	P4	Finance Section Head	Providing a financial service to station and regional requirement.	The post holder manages, directs and participates in the work of the finance section including budgets and station costs administration. Financial records, accounts, cash payments and fuel and ash payments are dealt with. He deals with the more important non routine aspects, makes decisions and finds solutions. Most of the time is spent on budgets. The provision of financial management services to the management team is another function for the post holder who also deputises with the station administrative officer occasionally.
A.4	P3	Technical Services Section Head.	To provide administration service in the works office, for contracts documentation and technical records. Also provide management information [illegible]	The Section Head manages, directs and participates in the activities of the contract, works office technical records and information display sub-sections including the operation of the visual display unit. He also devises and introduces statistical systems to better interpet the data available at the location. Station performance is monitored against a station plan on behalf of management.
A.5	P3	Stores Section Head.	To ensure that an efficient stores and purchasing service exists on the site.	He manages, directs and participates in the various stores activities. Generally concerned with the non routine matters and making decisions in relation to them. About half his time is concerned with goods procurment and stock holding levels.

2000MW COAL FIRED POWER STATION - ADMINISTRATION POSTS

TABLE A..5

SUMMARY OF JOB DESCRIPTIONS

STAFF TREE NO	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS
A.6	P3	Salaries and Personnel Section Head.	To ensure the salaries and personnel section provides a complete and efficient service in accordance with boards procedures.	The post holder manages the work of the section and is involved in all parts including pay roll procedures, staff records and manpower statistics, industrial relations and welfare facilities. The more important or non routine aspects are generally dealt with by the post holder as our confidential matters. Certain checking duties are carried out personally by the post holder.
A.7	P1	Financial Assistant	To assist managing the daily routine of the finance office. To accurately process the station budget and cost control systems.	The post holder maintained an overall view of the work of the section and deputises for the Section Head. The main task is monitoring Capital and Revenue Expenditure against budgets and following up large avariences. Also monitoring future commitments against budget. Preparation of annual budgets is another main task. These duties occupied 2/3 of the time the remainder being spent on sundry duties.
A.3	C3	Senior Technical Records Clerk.	To provide accurate technical summaries and statistics for R.H.Q. and a similar service for the station.	The work is mainly concerned with carrying out calculations from recorded data to provide statistical information on daily, weekly and monthly bases. In addition to the routine the post holder will develop a new procedures and provide specialised information when required. Deputising for the section head is another occasional task.
A.9	C3	Contracts Senior Clerk	To ensure that all non engineering aspects of contracts are effectively controlled.	The preparation of contract specifications from the basic data and requirements provided by engineers. Subsequently providing administrative monitoring of contracts through all stages.
A.10	C3	Works Office Senior Clerk.	To ensure that administrative support services are provided for the short term planning and works office functions.	In addition to performing some of the tasks of this office the post holder generally supervisors the team of clerks asociated with this work. Problems arising from the work flow are dealt with and a general monitoring function is carried out. Much of the post holders time is spent in cost coding defect cards and dealing with queries from engineers.
A.11	P1	Purchasing Administrative Assistant.	Ensuring that the daily routine administration of the Stores and Purchasing Office is carried out effectively.	The primary responsibility is in relation to the purchasing aspects of the sections work. Half the post holders time is spent in buying and especially direct charge buying. The remaining time is spent covering a range of duties including deputising for the Section Head.
A.12	C3	Cashier.	To provide disbursements and cash supplies at all times; ensure that cash, banking and payments are securely carried out in accordance with procedures. To monitor the financial integrity and provide a financial service for the canteen and sports and social club.	The handling of all monies is the responsibility of the post holder including the making of payments of pay, expenses, restaurant takings and Sports and Social club monies. Acurate records of all these transactions have to be maintained by the post holder. The post holder [illegible] responsible for the associated duties of the assistant clerk.

2000MW COAL FIRED POWER STATION - ADMINISTRATION POSTS

TABLE A..5

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS
A.13	C3	Accounts Senior Clerk	To keep records of all fuel deliveries ash and other such movements so that payments claimed by suppliers can be checked and certified for payment. To ensure that stores issue notes etc are accurately costed to provide cost statements to management.	Keeping record of fuel deliveries, following up anomalies and investigating short-falls. Checking coal delivery invoices, preparing R.H.Q. returns on fuel. These fuel monitoring duties occupy about two-thirds of time. Most of the remaining time is spent making cost allocations on stores issue notes.
A.14	C3	Office Services Supervisor.	To ensure that efficient administration support services such as typing provided for the rest of the station.	Organising the work of three sub-groups namely:- typists, reception and telephone, registry and office services. Also personally directing postal services, writing local procedures and reference books, supervising the stationery store and keeping accident records. Providing basic administrative training and organising administration services for other departments are also functions of the post holder.
A.15	P1	Personnel and Salaries Assistant.	To ensure routine administration of the personnel office is effective and that regional requirements are met on time.	Supervising the day to day administration of the personnel office. Preparation of salaries for industrial staff and checking the records. Administrative matters relating to vacancies, appointments, staff induction etc. Deputising for the section head on occasion.
A.16	C3	Restaurant Manageress.	To provide:- luncheon service for all station staff; twenty-four hour food service using vending machines; special meals service for meetings, functions and VIP's.	Management of the restaurant and kitchen staff, maintaining good human relations and dealing with personal problems. Determining menus, ordering supplies, checking stocks and programming work. Cooking special meals occupies a quarter of the post holders time.
A.17	C3	Stores Progress Senior Clerk.	To speed the delivery of goods and services and overcome problems when possible.	The main task is progressing outstanding orders and to provide an alternative supplies service when possible. Building up a bank of information relating to suppliers and advising engineers on availabilities.
A.19	C2	VDU Operator.	To use the VDU for computer input data and the extraction of information subsequently.	About half the post holders time is converting work order card data into computer print-outs. Other station statistical data is processed using the regional computer programmes and the results analysed and interpreted by the post holder.
A.20	PS2	Private Secretary for S.M.	To provide an efficient secretarial service for the Station Manager and his deputy.	Sorting, filing, retrieving information from private files: dealing with telephone enquiries and maintaining appointments diaries for the Station Manager and the Deputy. Providing a dictation and typing service for both and keeping records, manuals and other information updated. Carrying out occasional administration tasks.

2000MW COAL FIRED POWER STATION - ADMINISTRATION POSTS

TABLE A.5

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS
A.21	C2	Technical Records Clerk.	To ensure that technical data for the production of technical records are accurate, readily available and clearly presented.	The work mainly comprises collation and processing of data relating to station plan and producing records and returns from them. Also updating the station plan displays and other progress records. Much of the work is carrying out calculations on data obtained from various sources.
A.22	C2	Purchasing Clerk.	The provision of systematic and efficient progressing of buying processes.	Over half the post holders time is dealing with buying systems and the enquiries arising from them. Also monitoring special orders and making amendments to codes and catalogues are other substantial duties. This set of duties is changed regularly with those of another stores clerk.
A.23	C2	Stores Clerk.	Maintenance of stock record by recording issues and receipts.	Sorting stores issue notes and stock receipt notes. Dealing with other aspects of goods receipts and checking availability. Commiting stores items to planned work. The post holder regularly changes this set of duties for those of the other stores clerk.
A.25	C2	Cash Clerk.	To assist in cash receipts, payments and records.	To generally assist the cashier and deal with routine aspects of the work. Filling pay-packets and servicing vending machines are two tasks occupying half the post holders time. The duties include restaurant takings, private sales, local purchase payments, Sports and Social Club machines and answering enquiries.
A.26	C2	Office Services Clerk.	To assist providing Office Services such as filing for the benefit of the station.	Wide variety of tasks are carried out including the filing correspondence. Copying and associated work occupies a quarter of the time. Sorting and distributing mail, making stationery issues are another area of work. Providing routine stand-by duties for various members of administrative staff is another function.
A.28	C2	Salaries Clerk.	To assist in providing effective personnel and salaries services on the station.	Much of the work is updating the payroll such as preparation of staff weekly work sheets and computer input documents. Also entering special payments. These duties total more than half of the post holders time. Checking the print-outs and giving information to staff members plus the maintenance of sickness records and preparation of statistics are other major duties.
A.29	C2	Salaries Clerk.	Assist in providing an efficient salaries service on the location.	Assisting in preparation of weekly work sheets showing attendance hours, sickness, holiday deductions etc. Preparation of data for the pay and productivity calculations and production of statistics. Keeping the station holiday records and dealing with requests for holidays. Organising pay advances for holidays. These specific duties occupy about two-thirds of the post holders time the remainder spent sundry minor station records.
A.30	C2	Works Office Clerk.	Providing clerical support services for the planning office.	Recording data on annual overhaul work order cards, preparing daily work order issue registers and amending man power availability records. These occupy one-third of time. Preparation of productivity scheme documents for operations staff and sorting cards for materials checking and time checking. These occupy more than half the post holders time. Preparation of work specifications for new tasks and sundry other duties. This post is one of four in the works office and the sets of duties change regularly.

2000MW COAL FIRED POWER STATION - ADMINISTRATION POSTS

TABLE A ..5

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS
A.31	C2	Works Office Clerk.	To provide a clerical support service for the planning office.	Sorting returned work order cards marking off completed items returning incompleted ones to engineers. Entering completed work in the logs and preparing work issue registers each day. Preparation of productivity scheme document other than for operations. Splitting work order cards for the history files. These duties are shared with the three other clerks.
A.32	C2	Works Office Clerk.	To provide clerical services for the planning office.	Assisting in the sorting of returned work order cards and preparation of work order registers each day. Preparation of scheme documents; the hours worked by each man have to be checked and entered on the summary sheets. Carrying out other related duties in the works office. The duties of this post are also shared with the other three clerks.
A.33	C2	Works Office Clerk.	To provide clerical support services for the planning office.	As with the other post main duty is sorting the returned work order cards, sending back incomplete cards and separating the others into the defects and preventative of maintenance groups. The defects on the log are cancelled and the cards returned to the work study section. Marking preventative maintenance cards when permits to work are required and indicating the type of permit. Sending un-timed cards to the works study for allocation. The duties of this post are regularly rotated with the other three posts for the works office clerks.
A.34	C1	Office Services Clerk.	To provide general clerical services where required on the location.	Much of the routine work such as filing correspondence, copying, binding, collating, stapling etc is carried out by the post holder. Also providing a stand-by service for absent members of staff or areas where work pressure is high.
A.36	C1	Clerical Stores Assistant.	To provide a clerical support services in stores section.	Much of the routine work of the stores comprises of copying documents, routine sorting documents and prepare records for despatch and filing etc. These duties are carried out by the post holder but also include general tasks with a view to providing basic administrative experience.
A.37	C1	Accounts Clerk.	Clerical assistance in recording fuel deliveries, weighbridge records etc.	Much of the routine work associated with fuel records is carried out by the post holder. Checking rail wagon weights and numbers against advised weights and weighbridge printouts occupies about a third of time. Dealing with ash sales, weighbridge tickets and checking oil tanker weighbridge tickets occupies another third of time. Most of the remaining time is spent summarising NJIC hours worked on a daily basis.
A.40	TEL	Telephonist/ Receptionist.	To provide an efficient telephone service and a helpful reception service.	Operating a telephone exchange occupies over half the time. Dealing with calls and visitors and with general enquiries occupies about a third of the time. Remaining time is spent doing routine typing as a "fill in" job.
A.42	S/ TYP	Shorthand Typist.	To provide a shorthand and audio typing service for the location.	Shorthand and audio typing occupies about two-thirds of the post holders time. Standing in as a Private Secretary occupies about fifteen per cent of the time, remaining time is spent on copy typing.
A.43	TYP	Typist	To provide a typing and audio typing service; to provide a stand-by and relief service for the receptionist and VDU operators.	Audio typing about fifteen per cent; copy typing about one third of time. Stand-by receptionist/ telephonist duties about a quarter of time (lunch-time). Relief duty for VDU operator about fifteen per cent of time.

of the levels of staff cover required for each post was made as a part of this study. Generally, the less skilled jobs required more cover. For example, the Telephonist/ Receptionist job needed 100% cover for absences which included lunch time breaks. Section Heads and the Departmental Head only needed about 1/3rd cover, i.e. an absence of ten days would require about three days of some one else's time. A system was devised to ensure that those providing cover were doing associated work, preferably in an immediately subordinate post.

The three areas of work with large volumes were:-

(a) The Stores stockholding and replacement systems with information being transferred to R.H.Q.

(b) The job card and productivity scheme recording system.

(c) The staff payment system, including the making-up of pay packets.

Each of the three systems is complex with hundreds of variations necessitating substantial volumes of clerical checking, collating and recording. Technical records and contracts control generally involved smaller quantities of data, but both were also closely linked with R.H.Q. Thus, these systems can be identified as absorbing the majority of the administrative labour on the site.

General Working Patterns

The working patterns of the industrial staff (N.J.I.C.) were not studied at this location, but some information about them was obtained. The general pattern for the maintenance work was to form the N.J.I.C. staff into shift or day work teams which were sub-divided into Mechanical, Electrical, or Instrument Groups. The Riggers and some Welders worked across the plant, but the majority of Welders were associated with the Mechanical

Section. Some N.J.I.C. staff had specific functions such as Battery Attendants. The shift Foreman had multi-craft skills, but usually those with complementary skills were grouped together on a shift. The average number of N.J.I.C. maintenance staff on duty on a particular day was 36 and the number on each shift was 18. Shift maintenance staff are primarily concerned with break-downs, but also carry out some routine work. The day maintenance do most of the routines and major jobs.

Flexibility of working was reduced by Management in order to increase the level of responsibility for plant by the N.J.I.C. staff. It is interesting to note that this was done at a time when the Board was generally seeking greater working flexibility from the N.J.I.C. staff. The result was to give the maintenance men responsibility for plant areas and operations men an association with one unit as a part of a unit crew. Information about the performance of units was published regularly in a general circulation journal and a feeling of pride and loyalty was building-up at that time. For the operations N.J.I.C. staff the equivalent of maintenance craftsmen are the operators and their assistants (two levels in effect). They monitor instruments, regulate plant, bringing in subsidiary items as required. The work of checking the plant, taking readings, samples and isolations is carried out by A.P.A.'s who would be classed as semi-skilled. Operator training is carried out in the Power Station and City & Guilds qualifications are usually obtained: the transition from unskilled to skilled takes about five years on average.

Seasonal work flows occur and in Summer the surplus operational staff are mostly absorbed by holiday needs. Usually one unit is shut down throughout the period.
At this Station some transfer of staff from operations to maintenance has been possible. The maintenance staff are

under considerable pressure during the period and the Manager said the transfer system worked, provided consideration was given to the feelings of the operations staff to avoid them being treated as unskilled labour. The maintenance staff are further supplemented during annual overhauls by Contractors who carry out complete items of work. There is a general lengthening of the time scale in relation to jobs during the Summer period. Operations work is mostly short and medium term (as is break-down maintenance), but normal maintenance is medium and long term with thinking through problems being at the centre of the annual overhaul. These topics are developed further in Chapter 9.

A 2,000 M.W. Oil Fired Four Unit Station

The study carried out at this location was of the total range of tasks performed by the engineering staff as a precursor to their being redistributed within the new organizational structure. The tasks of each engineer under the present system were set down as a job description. The information was obtained from Section Heads, Departmental Heads and some from the Station Manager. All were subsequently examined by the Station Manager who used them as a basis for allocating work.

A brief summary of each engineer's job is set out in the Table A.6, together with the objectives of the posts and a brief statement of the role of the engineer which is included in the summary. The original job descriptions were analysed in a similar way to those in the previous study and percentages of time for each individual totalled under the four classifications of management, supervision, technical work and administrative duties. These figures have been listed for different categories of staff in Table A.7.

2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
X2	PE	Deputy Station Superintendent.	Co-ordinate Departmental activities; maximise station performance.	Short term planning, co-ordination, decision making and advising. Participation in policy formulation, technical problem solving and other technical matters. Monitoring work, safety and technical standards on the plant, maintaining good industrial relations. Various administrative tasks e.g. preparation of station plan and the manuals; conducting staff interviews and authorisations. Deputising for the Station Manager. Dealing with personal problems. In management and day planning teams; communication links with many staff levels.	25	20	35	20
01	PE	Operations Superintendent.	Organising plant operation to system requirements and optimising efficiency, availability and economy.	Co-ordinating operations work, making decisions, obtaining information, dealing with technical problems. Dealing with administrative aspects, maintaining good human relations. Assisting in the station policy formulation, budget control and station problems. Acting as a communications centre for operations and providing links with other station staff and outside organisations.	25	5	35	35
02	SE	Station Chemist.	Organise and supervise station chemical services and certain support services, e.g. photography.	Administrative aspects, personnel problems and industrial relations. Chemical advisor at meetings and in policy formulation discussions. Investigating certain chemical technical problems. Outside representative on pollution problems including lectures. Monitoring and supervising work of the branch.	10	10	55	25
03/7	SE	Shift Charge Engineers.	To ensure plant operated in accordance with work programme and to maximise efficiency security and availability. To take emergency action.	Supervise all work on plant, monitor operations. Investigate faults, discuss problems, make decisions. Handle administrative aspects, maintain good industrial relations, monitor training, check equipment availability. Prepare station log, reports when appropriate, discuss problems with maintenance engineers. Make permit to work decisions, vary working programmes if appropriate. As leader of shift team the SCE is responsible for communicating with day staff.	25	30	20	25
010	1E	Assistant Station Chemist.	To provide site support services including chemical plant monitoring and enforcing statutory regulations.	Checking and ordering of chemical stocks and supplies. Monitoring routine chemical analysis. Carrying out more complex analysis. Investigating pollution problems; deputising for station chemist.	5	40	30	25

'2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
011/15	1E	Assistant SCE (Control)	To operate plant in accordance with working programme.	Post holders have responsibility for plant on a very short term basis. Are instantly available for operation decisions and continuously monitoring plant. Carrying out remote switching and organising checks on state. Discussing requirements with other staff dealing with enquiries from System Operations. Organising resources and facilities with day staff and dealing with enquiries. This job is changed with that of the other assistant SCE on alternative shifts.	10	25	35	30
017/21	1E	Assistant SCE(Plant)	Identify plant operating problems, find solution prepare and release plant for maintenance.	Organiser and monitor of work on operating plant. Investigate requests for permits to work, organising isolations, issuing permits. Checking completed work, cancelling permits. Investigating plant faults, taking measurements, advising on action. Checking on staff work, maintaining good industrial relations, assisting in training needs. Writing technical reports, communicating with other staff, especially shift maintenance and day maintenance. This post changes each shift with the assistant SCE control.	0	25	50	25
022	1E	Day Operations Engineer	Facilitation of maintenance work during outages, re-commissioning and checking safety systems.	The co-ordinator and organiser of day operations and particularly the permit system, the plant re-commissioning service and testing of alarm and control circuits. Organising branch work co-ordinating activities with other branches and discussing requirements with engineers. Monitoring work and assisting when pressure is high, providing support for industrial staff. Reviewing testing procedures, co-ordinating permit requirements and re-commissioning work during major outages. As leader of day operations team post holder provides essential services for shift staff.	10	25	45	20
030	2E	Assistant Plant Chemist	To monitor plant chemical condition and take corrective action. Provide a site photographic service.	Monitoring chemical plant and dealing with problems, making technical decisions and dealing with adverse conditions. Supervising oil sampling and discharge of chemicals. Taking photographs when required.	0	25	60	15
031	2E	Assistant Laboratory Chemist	Routine and non routine chemical analysis.	To carry out routine and some more complex analysis including water sampling, trace metals, machine oils. Various non routine analysis.	0	0	90	10
032/36	2E	Assistant Operations Engineers	Isolation and preparation of plant for maintenance; investigating plant operating difficulties.	Investigating faults, taking measurements and resolving difficulties if possible. Isolating plant, issuing permits, checking plant on completion and cancelling permits. Discussing work needs with the shift maintenance engineer and supervising work on plant by industrial staff. Acting as relief for the assistant SCE when required.	0	35	40	25

2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
037	2E	Assistant Permit Engineer.	To provide permits according to procedures and facilitate maintenance work.	To provide continuity and administration in the permit system. The tasks vary and in summer providing permit service during outages and a continuing service for operating units. In winter a permit system for operating sets and administrative control of the permit office. Organising permits for minor outages and investigations of the permit system.	0	30	40	30
038	2E	Assistant Day Operations Engineer.	Ensure plant security systems are reliable.	The checking of plant and security system. Checking and off-line operations of plant items after maintenance before going into service. Systematic checking of interlocks, trip circuits alarms and system interlocks. Testing of special items and updating procedures.	0	10	70	20
040/44	2E	Relief Engineer Operations.	To provide shift cover for holidays and other absences.	A supporting member of the shift team carrying out duties of the assistant operations engineer forty per cent of the time and the duties of the two assistant shift charge engineers also forty per cent of time. Remaining time is on specific projects of a minor nature.	0	20	55	25
050/54	3E	Shift Chemists	Continuous monitoring of plant chemical conditions.	Continuous chemical analysis of water and fuel oil. Monitoring water treatment plant and certain routine chemical analysis.	0	10	70	20
056/57	3E	Assistant Engineer Day Operations.	Testing of safety systems on the plant and re-commissioning of plant after maintenance.	Routine interlock and safety system checks. These tests are carried out on a three monthly basis and involve working on the plant injecting signals and systematically completing procedures. Faults rectified when possible.	0	10	80	10
M1	PE	Maintenance Superintendent	To devise, manage and supervise maintenance systems at the locations and to assist in station management.	As departmental manager he co-ordinates, makes decisions and provides technical guidance. As a member of station management he assists in overall policy and carries out specific tasks. The co-ordination of day to day maintenance work, monitoring work on plant, decisions on non routine problems and providing communications. Dealing with administrative matters, maintaining good industrial relations, attending interviews and investigating supply problems. Post holder is a member of the station management team and the maintenance management group. Strong individual links are maintained with other members of staff at the location.	25	10	35	30
M2	SE	Electrical & Instruments Maintenance Engineer	To ensure light electrical and instrument equipment is maintained effectively in accordance with station requirements.	As a branch head and manager he deals with day to day matters in the light electrical and instrument field making decisions and giving technical advice. The co-ordination of day to day work includes visiting plant, monitoring progress and maintaining good industrial relations. Implementating management decisions and reporting progress, discussing long term requirements, checking on contracts and supplies. Discussing technical problems, considering alternatives, preparing budgets.	15	20	40	25

2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A..6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (%, of Total Time)			
					Man.	Sup.	Tech.	Adm.
M3	SE	Mechanical & Heavy Electrical Maintenance Engineer.	Ensuring that mechanical & heavy electrical equipment is effectively maintained in accordance with the station requirements.	Managing the day to day problems associated with maintenance, making decisions and giving technical advice. Visiting the plant, monitoring progress and maintaining good industrial relations. Implementing management decision, reporting progress, discussing long term requirements. Checking on contracts and supplies discussing technical problems with engineers. Dealing with various administrative methods.	15	20	40	25
M6/ 10	1E	Mechanical & Heavy Electrical Shift Maintenance Engineers.	To facilitate routine maintenance and provide a break down service for mechanical and electrical plant.	As senior maintenance representative on shift he advises, guides and sometimes modifies the programme. Co-ordinating maintenance work, re-allocating work with the shift foreman and fitting in with operating requirements. Dealing with administrative aspects, arranging spares, maintaining good industrial relations, organising rotas. Inspecting plant, investigating faults, testing and checking. Dealing with technical enquiries and giving advice to industrial staff and operation staff. Carrying out technical investigations.	10	35	45	10
M11	1E	Assistant Heavy Electrical Engineer.	Ensure the maintenance of heavy electrical equipment is optimised consistent with station requirements, safety, etc.	The post holder is the heavy electrical specialist and has a prime responsibility for the state of that plant. The other role is managing the heavy electrical maintenance section. Carrying out technical investigations, dealing with technical problems, assessing plant performance and giving advice. Preparation of reports and specifications, monitoring contract work in progress. Supervising maintenance work in progress and monitoring the standards. Carrying out general administrative duties including training and deputising for the maintenance engineer. Maintaining good industrial relations.	10	15	50	25
M12	1E	Assistant Mechanical Engineer.	Ensure mechanical equipment on site is maintained in accordance with station requirements i.e. optimising availability, efficiency and reliability in accordance with safety and economic considerations.	As the mechanical engineering specialist the post holder has prime responsibility for the state of the mechanical plant. The other role is to manage the mechanical section. Giving technical advice, guidance and decision on mechanical plant including gas turbines. Monitoring the work of the industrial staff and of contractors, discussing problems. Preparing reports work specifications and making recommendations for contracts. Carrying out site investigations including weld investigations.	10	35	35	20
M16	1E	Assistant Light Electrical Engineer.	To ensure light electrical circuits and equipments have availability and are effective. To make improvements which are economically viable.	The post holder is the specialist in light electrical equipment on the site and is also section head of the appropriate maintenance group. Managing the routine work in relation to the plant, monitoring progress and giving technical guidance and decisions. Holding discussions with other engineers, co-ordinating work and discussing technical problems. Providing technical advisory service, carrying out test on plant devising solutions to problems. Preparing drawings, specifications and contracts and monitoring progress of work. Dealing with administrative aspects, providing some training for junior engineers and maintaining contacts with outside bodies including planning.	10	15	50	[illegible]

2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
M17	1E	Assistant Instrument Engineer	To ensure instrumentation at the location is maintained in an effective condition to carry out improvements which are economically and technically worth while.	The post holder is the technical expert for instruments and control systems on the site and is also responsible for the day to day work of the appropriate section. The organising of maintenance work in the short term and associated administrative duties include training and lecturing and the technical needs for long term planning. Investigating instrumentation problems on the plant, contacting manufacturers, monitoring work in progress. Belonging to working groups dealing such aspects as instrumentation, computer controls, etc.	10	10	50	30
M20	2E	Shift Relief Engineer	To provide a 'stand in' for the Shift Maintenance Engineers during absence.	For most of the time the post holder is on shift carrying out the duties of the shift maintenance engineers. Briefly these are the coordinations of maintenance work and modifying the programme when required to fit in with the shift operating requirements. Inspecting plant, investigating faults, dealing technical enquiries and giving advice. At other times the holder will carry out technical investigations and 'one off' minor problems associated with the plant.	10	35	45	10
M23/27	2E	Shift Maintenance Engineers electrical and instruments	To provide technical service and guidance for light electrical and instrument maintenance and also a break-down service.	These Engineers provide problem, solving expertise for the electrical and instrument plant and manage the routine work in progress. Taking measurements on the plant, carrying out checks and fault identification and the monitoring of work in progress are the main tasks. Investigating faults, discussing problems with operations engineers and varying the plant programme when appropriate are the responsibilities and duties.	0	15	65	20
M31	2E	Computer Engineer	To maintain the computer and associate equipment in working order.	The post holder is primarily a specialist electronics engineer dealing with computer systems and investigates defects, taking measurements identifying faults and issuing job cards. Carrying out test runs on the computer changing modules and repairing defective modules. Maintaining up-to-date records and drawings and running an efficient computer work-shop. Discussing requirements with the system analyst and operations staff. Modifying the computer system if required and providing technical advice out of hours.	5	15	60	20
M32	2E	Electrical Protection Engineer	To check regularly all the electrical protection equipment.	As the specialist professional engineer dealing with protective equipment he carries out and records equipment checks in accordance with a programme. Also technical investigations into problems and preparation of reports. Provides training for industrial staff on the equipment.	0	5	70	25

2000MW OIL FIRED POWER STATION, NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
M33	2E	Buildings Engineer	To ensure buildings and site services are maintained to appropriate standards. To provide transport and fire-fighting systems on the site.	Discussing maintenance requirements and additions to buildings etc., producing schemes, preparing specifications. Organising contract work, acting as clerk of the works for larger contracts, monitoring continuing contracts such as office cleaning. Monitoring routine work, discussing requirements for the foreman. inspecting work areas, checking fire-fighting equipment organising training of fire-fighting teams. Dealing with administrative matters leave and general training.	5	25	20	50
M35	2E	Assistant Long-Term Mechanical Engineer	That mechanical and heavy electrical resources for outages are available and efficiently planned and programmed.	The post holder is primarily a long term coordinator of resources concerned with the preparation of work schemes and programmes. Discusses requirements with engineers, coordinating with electrical and instrument maintenance and preparation of programmes. Pre-planned requirements are slotted in and net-works prepared. The net-works are discussed, modified and man power requirements assesed. Work specifications and work order cards are prepared and materials and tool requirements checked. Contract programme is prepared and progress on supplies and contracts is monitored. The programme is finalised and handed over to the outage manager.	0	5	50	45
M36	2E	Assistant Short-Term Mechanical and Heavy Electrical Engineer	To coordinate and plan mechanical and heavy electrical work provided this is achieved effiecently and economically.	The post holder is the short term coordinator and planner of mechanical and heavy electrical work. Work items are directed to appropriate engineers, as priorities are asseséd and progress is monitored. Short term plans and schedules are prepared with high priority work slotted in. Delays are investigated and engineers kept informed. Materials stocks are checked and tasks for shut downs are allocated. Work order cards, works specifications index and plant history records are organised and resource records are kept.	5	5	25	65
M37	2E	Assistant Long-Term Light Electrical and Instrument Planning Engineer	To insure that light electrical and instrument resources are planned and programmed for outages.	The post holder is a long term coordinator of resources that is primarily concerned with preparation of work schemes and programmes. Requirements are discussed with the engineers, and coordinated with the mechanical and heavy electrical programmes. Pre planned requirements are slotted and net-works prepared. These are discussed, modified and work lists devised. Manpower requirements, materials and tool requirements and contract programmes are prepared. The progress of supplies availabilities is coordinated into a final programme.	0	5	50	45
M38	2E	Assistant Light Electrical and Instrument Short-Term Planning Engineer	Coordination and planning of light Electrical and Instrument work-load for efficiency and economy whilst maximising plant availability.	The post holder is coordinator and planner of light electrical and instrument work in the short term who directs work requirements to the appropriate engineers and asseses priorty and progresses work. Short term plans and schedules are prepared with high priorty work being slotted in. Delays are investigated and information provided for engineers. Major shut down tasks are transfered to the long-term engineer and work order cards, work specification indices and history records are built up.	5	5	25	65

2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A .6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
M40	3E	Draughtsman	To provide a drawing service on the site and maintain a complete and updated set of drawings of the plant.	Finding and indexing drawings, making copies from existing drawings. Obtaining from RHQ or manufacturers and modifying drawings when required. Preparing drawings from engineers sketches.	0	0	40	60
M42	3E	Assistant Heavy Electrical Engineer	To ensure certain heavy electrical plant is technically supervised.	To provide engineering skill in electrical fields. Preparation of work specification work order cards, spares stock lists and preventative maintenance schedules. Investigating plant problems, carrying out tests, taking measurements and devising solutions. Designing plant modifications, preparing contracts and budgets. Ordering spares, checking work of contractors and testing modified plant.	0	5	60	35
M43/45	3E	Assistant Mechanical Engineers	To provide engineering support services for mechanical plant items.	To provide engineering support in mechanical fields. Preparation of work specifications, work order cards, spares stock lists and preventative maintenance schedules. Investigating plant problems, carrying out tests, taking measurements and devising solutions. Designing plant modifications, preparing contracts and budgets and ordering spares. Checking work on the plant including contractors work and testing modified plant.	0	5	50	45
M46/48	3E	Assistant Instrument and Light Electrical Engineers.	To provide engineering support in the instrument and electrical fields.	Preparation of work specifications, work order cards, spares stock lists and preventative maintenance schedules. Investigating plant problems, carrying out tests, devising solutions. Designing modifications, preparing contracts and budgets, ordering spares and checking contractors work and equipment. Technical monitoring of work on plant and testing.	0	5	50	45
M50/60	3E	Assistant Engineers	To provide general engineering assistance on the station. To give plant experience to theoretically qualified engineers.	Over three to four years the engineers progress from tasks designed to aid their experience gaining to the performance of tasks of value to the overall station performance. They carry out technical investigations of increasing complexity and resolve problems. Other work is preparation of contracts, budgets, the technical supervision of work and pre-commissioning tests. They assist as members of the major outage teams.	0	0	90	10
T1	PE	Performance and Resources Superintendent	To provide planning, resource allocation, test and efficiency, development and computer services on the site.	As a departmental manager he will co-ordinate, make decisions and provide technical guidance within the department. As a member of the station management team he will assist in policy formulation and carry out tasks. Co-ordinating the day to day work of the department, maintaining liaison with other power stations and RHQ, monitoring the work of the plant, providing communications and decision making. Dealing with specific technical matters, thinking through solutions and implementing them. Dealing with general administrative matters, maintaining good human relations, and attending interviews and investigating personnel problems.	20	10	45	25

2000MW OIL FIRED POWER STATION. NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTION

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
T2	SE	Development Team Leader.	To direct development projects intended to improve plant performance and reliability.	As the leader of the branch dealing with major problem solving facilities, he discusses problems with other engineers on the site, investigate requests from RHQ and other members of the staff. Problems are discussed with members of the development team, work is allocated, technical aspects and solutions discussed and decisions made. Work in progress is monitored, reports prepared, specifications and contract documents prepared and proposals discussed with Management. Technical investigations are carried out by the post holder who will think through solutions, take measurements etc. Deputising for the performance superintendent is carried out.	5	25	45	25
T3	SE	Planning Engineer.	To organise the station work load planning so that it is carried out efficiently, using the minimum of resources.	As planning manager the post holder co-ordinates with a short term, long term, and associated functions of method and work study. Providing a feed back link to management he directs programme changes and discusses policy with the senior staff. Planning progress is monitored and decisions and advice given to members of the branch. Reports are prepared and planning systems reviewed. Special requirements are investigated, calculations and analysis of data carried out.	25	25	25	25
T4	SE	Test and efficiency Engineer.	To provide a plant measurement and monitoring service, to optimise plant performance.	As a section head he is responsible for plant monitoring and providing test services. He carries out normal administrative duties including the checking of work and providing information for other station staff. Test results are checked and investigations of anomalous results arranged. Technical advice and guidance is provided for staff together with information and instructions. Certain special investigations are carried out by the post holder.	10	10	50	30
T6/ 7	1E	Work Study Engineers.	To ensure that work on site is measured for the pay and productivity scheme.	As leader of the group which measures all the work carried out on site the post holders main tasks are managing and organising the work study assistants and ensuring that new work is measured and routine work is completed. Decisions are made on problems, enquiries from shop stewards and foreman are dealt with and occasional checks carried out. Performance figures are analysed and control checks carried out. Other duties including training of work study assistants and dealing with general enquiries. Providing a stand-in for the short term planning engineer is another function.	10	25	15	50

2000MW OIL FIRED POWER STATION, NJB POSTS

TABLE A .6

SUMMARY OF JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	NATURE OF TASKS (% OT TOTAL TIME)			
					MAN.	SUP.	TECH.	ADM.
T8	1E	Methods Study Engineer	To find improved methods of performing work at the location.	Investigating method study requests, analysing work on plant, deciding whether studies are worthwhile. Allocating work priorities, setting up procedures and discussing projects with the Planning Engineer. Informing all interested persons and groups, carrying out the studies, analysing results and discussing with Departmental Heads. Providing work cover for the Works Office Engineer.	5	15	60	20
T9	1E	Assistant Long Term Planning Engineer	The collation of relevant data and production of work plans and programmes for major outages.	As leader of the long term planning group he discusses plant requirements with engineers, main suppliers and contractors. The production of planning networks with the work slotted in is followed by a computer analysis and a subsequent working programme preparation. The monitoring of programmes in progress includes recording changes and improvements for future programmes and thinking through new procedures.	5	10	55	30
T10	1E	Assistant Short Term Planning Engineer	To organise and co-ordinate work at the location in the short term. To provide a communication and information centre.	Monitoring and supervising the sections work, giving advice and guidance and making decisions. Co-ordinating routine work at the station during the morning meetings. Holding discussions with engineers to monitor work progress and giving information to engineers management, etc. on the state. Allocating work in accordance with resources available and planning work up to three weeks ahead. Informing other groups of future intentions. Preparing a daily work programme and allocating work between day and shift staff. Preparing networks for minor outages. Re organising work at short notice to accommodate defects and adjusting overall plans to accommodate special plant problems.	5	25	40	30
T11	1E	Systems Analyst	To provide information enabling operators and maintenance engineers to perform work more efficiently.	The post holder is leader of the group providing computer facilities at location and dicusses needs, assesses data and advises on information systems. Monitoring existing computer use, investigating better facilities, providing guidance. Directing the programmer's work, maintaining close liaison with R.H.Q. Computers and with Computer manufacturers. Identifying the system failures, finding causes and taking corrective action. Analysing printouts to provide data on planned malfunctioning.	10	20	60	10
T12	1E	Assistant Test and Efficiency Engineer	To provide data to improve overall plant performance.	The post holder is leader of the Test and Efficiency Field Team and directs and supervises the NJIC day operations team. Organising, analysing and carrying out vibrational work. Analysing and monitoring routine efficiency calculations. Carrying out special checks, tests on plant and inspection of plant items. Carrying out specific investigations and major outage duties.	10	30	50	10

2000MW OIL FIRED POWER STATION, NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	NATURE OF TASKS (% OF TOTAL TIME)			
					MAN.	SUP.	TECH.	ADM.
T20	2E	Safety Officer	To ensure statutory and safety regulations are complied with. To encourage and develop safe working practices.	As the Safety Specialist at location, the post holder advises, guides and directs in all aspects of safety. The investigation of accidents and incidents, the preparation of reports and making statutory returns are main tasks. Monitoring working practices, investigating plant areas and considering improvements. Devising and implementing safety reward schemes, investigating safety hazards reports. Organising training courses and giving lectures.	5	25	30	40
T23	2E	Computer Programmer	To provide a computer programming service at the location.	Monitoring computer operation, giving information and data to the operations and maintenance engineers. Running special programmes for operators and checking faulty results. Updating input references and other administrative tasks. Liaison with RHQ and other station staff using similar programme. Carrying out programme modifications, investigating faults and providing special programmes for maintenance or operations. Carrying out programme trials and planning future requirements,	0	10	70	20
T24	2E	Assistant Boiler Test and Efficiency Engineer.	To optimise boiler plant availability by providing technical data.	Checking boiler performance data from records, discussing the state of the boilers with the operations engineer, noting deviations and reporting major deviations. Investigating combustion problems, carrying out physical checks on the boiler and organising the maintenance requirement on the burners. Checking air heater seals, carrying out oxygen surveys and examining boiler expansion joints. Carrying out internal boiler inspections during overhaul, examining emission plant and analysing boiler water usage data. Carrying out special boiler investigations and assisting in other tests which require more than one engineer.	0	5	65	30
T25	2E	Assistant Turbine Test and Efficiency Engineer	To assist Operations and Maintenance departments to optimise turbine plant performance.	Carrying out routine daily checks on plant measurements, investigating anomalous results and advising both Operations and Maintenance on relevant conditions. Carrying out measurements and calculations on the plant and assessing condenser air leaks. Organising maintenance requirements when appropriate. Arranging for instrumentation on the feed heater performance and carrying out tests including calculations. Carrying out performance tests on feed pumps and other such plant items. Measuring the heat rate on turbines and various non-recurring measurements such as vibration or turbine crack detection.	0	15	75	10
T28	3E	Training Engineer	To supervise and organise training facilities at the location.	To collate station training needs and prepare plans and budgets. To maintain training records, arrange courses and deal with problems. To organise and manage internal courses, give lectures and run induction courses. To organise routine visits to the station, to train and direct the lady guides. To give lectures to outside establishments such as schools.	5	10	35	50

2000MW OIL FIRED POWER STATION, NJB POSTS

TABLE A.6

SUMMARY OF JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% of Total Time)			
					Man.	Sup.	Tech.	Adm.
T30/35	2E	Assistant Development Engineers	To carry out plant modifications of a major nature which will improve its performance.	Checking plant operating conditions from measurements, records, enquiries and observations. Holding discussions with engineers, thinking through the problems, contacting other outside groups in seeking solutions. Developing ideas, assessing viabilities and cost and preparing sketches. Producing drawings and specifications, making budgetary allowances, checking tenders and making recommendations. Monitoring work in progress, testing completed items and checking on subsequent operations.	5	15	65	15
T40	3E	Assistant Test and Efficiency Engineer	To assist in routine measurements on the plant.	Performing vibration monitoring, collecting data, comparing with previous records, noting changes and advising operations and maintenance engineers. Measuring gas boiler pressure, comparing the standard conditions and assessing plant state. Measuring water losses due to steam leaks by measuring water levels. Checking fuel stocks, measuring foundations settlements, checking for water and gas leakages. Checking leak measurement equipment and carrying out acoustic checks.	0	10	80	10

Table A.7

Analysis of Time Allocation for Engineers at a 2,000 MW Oil Fired Power Station

Staff Departments & Groups	No	% Time Spent On			
		Man	Sup'v'n	Tech	Admin
Managers	4				
Operations	40	6	22	48	24
Maintenance	42	4	12	59	25
Technical Services	22	7	15	46	32
Total	108				
Managers	4	24	11	38	27
Operations Shift	25	7	27	40	26
Chemist	9	2	14	65	19
Day Operations	6	6	15	58	21
Shift Maintenance	11	5	26	54	15
Day Maintenance	31	4	7	61	28
Planning	8	9	20	34	37
Development	7	5	13	41	41
Efficiency & Computers	7	4	14	65	17
Average NJB	108	5	17	52	26

It perhaps should be noted that the figures do not contain the times for the Station Manager which would significantly increase the management and supervision figures for the Managers. The figures surprisingly indicate that the pattern of work for development is similar to that for planning with an understandable reduction in the time spent on management and supervision. The Chemist and the Efficiency Engineer both spend a high proportion of their time doing technical work. Referring back to Table A.6 it can be seen that those engineers in the less senior posts in all departments spend negligable proportions of their time on management or supervision, but spend a surprisingly large amount of the total time on administrative tasks. This again was interestingly reversed for the most junior engineers who always appeared to spend nearly all their time on technical work.

As in the case of the previous station an attempt was made to evaluate the time spent by engineers on work which could be classed as plant improvement (development) work and the time spent on planning functions. The figure obtained for development work was equivalent to 12 staff and the figure for planning was equivalent to 16 staff. In the same way as before these figures should be regarded as minimum ones because some planning work and a considerable amount of development work is inherent in the day-to-day work of most of the engineers. Using the set of job descriptions an attempt was made to assess what proportion of their time was spent working on the plant, or carrying out directly related functions such as analysing plant measurements. Activities such as managing, monitoring, facilitating and fulminating were specifically excluded. The group with the highest value was the Test & Efficiency Engineers, together with some of the day Operations Engineers whose duties were not dissimilar. Most of the Chemists spent a substantial proportion of their time performing analyses or measurements. Operations staff had variable results and those on shift spent an average of half their time on such plant orientated work. Much of this was associated with isolations and permits. Those engineers spending least time on work directly associated with the plant seemed to be the Maintenance Engineers with the exception of the most junior ones and the Protection Engineer.

The Station Manager's view of the new structure was to allocate responsibility and accountability for plant types and plant areas to individual engineers within the Engineering Services Department. These engineers were expected to decide what needed to be done on the plant and when it was in a fit condition to be operated. The substantial number of engineers within this department would monitor the plant and work done on the plant and would also give advice and guidance to the production staff who operated the plant. The Production Department's main responsibility was to manage the plant operation and also take responsibility for the majority of the industrial staff on the Station. The Resources Department's main responsibility was to obtain and deploy the resources which were necessary to meet the requirements of the Engineering Services Department. They also planned work and kept plant records. Part of the thinking behind the overall structure was to ensure that groups of staff were generally monitored by other separate groups. Plant operation would be monitored by Engineering Services and their use of resources monitored by the Resources Department. The Resources Department would be monitored in terms of work output by Engineering Services and monitored by Production in terms of their resource deployment. Engineering Services would be mainly monitored by Station Management in terms of plant reliability and efficiency, with a restraint on profligate use of resources being imposed by the Resources Department. That, briefly was the proposed new organization for the Station. Before discussing the research carried out at the next location there are one or two other items relating to working patterns to be noted.

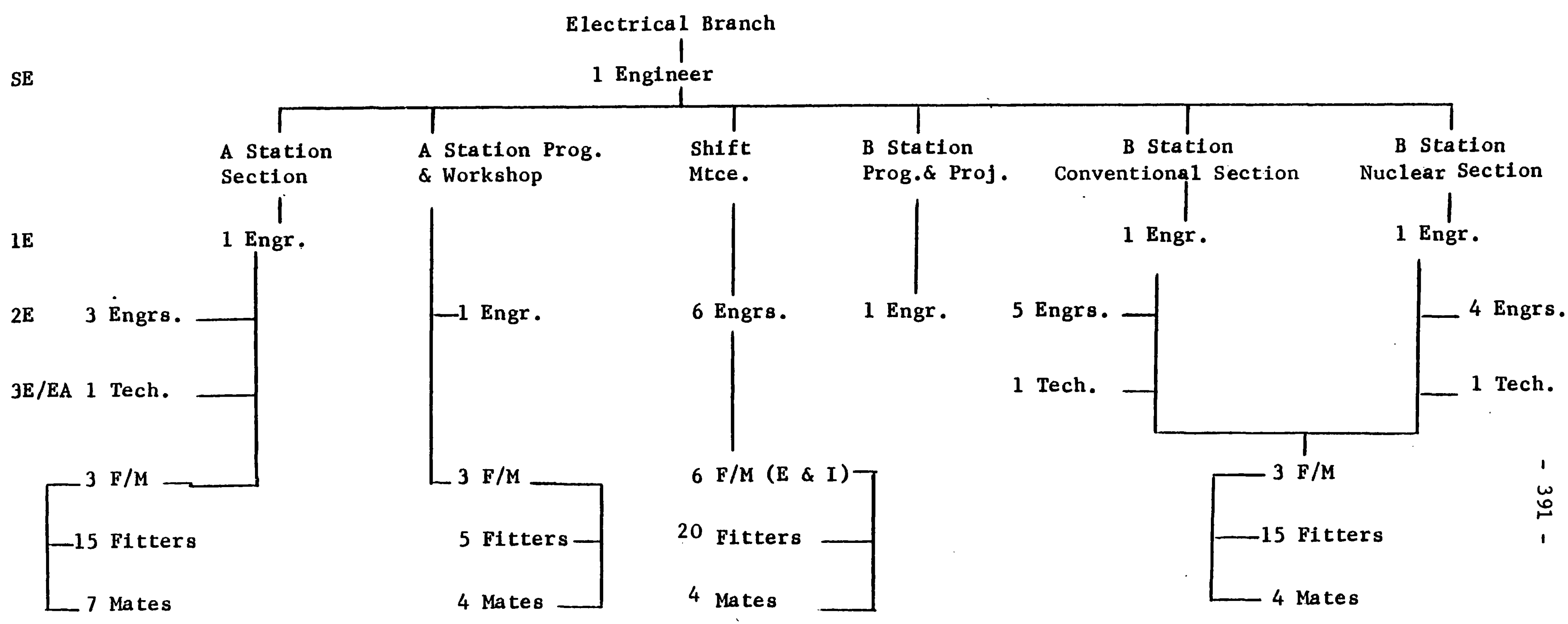
Some work measurement has been carried out in relation to several engineers' jobs at this location, one of them being the issue of Permits to Work. Many isolations on the plant have to be carried out by the engineer, particularly those involving high voltages. Others are carried out by industrial staff under the direction of a Foreman, but these are invariably checked by the engineer before signing the Permit. Sometimes Permits are signed without checking being carried out, but only if the isolation involves no form of danger. An example would be domestic cold water supplies. It was found that the total Permit workload would occupy more than one person full time on each shift. Also, the Permit workload varied with peaks ahead of outages. With the majority of isolations carried out by industrial staff the system involves triple checking in most cases. The work is considered to be repetitive, uninteresting and technically not demanding. Many other examples were given of work at this location which did not require professional engineering abilities for its execution. The examples are routine chemical analyses, efficiency tests, planning, work study and a great deal of routine maintenance. The Maintenance Superintendent took the view that the Departmental work levels could be judged by the budgets and pointed out that the Maintenance budget was seven times the size of the Operations one. From the information given it seemed that the procurement of supplies was generally a problem for the Maintenance Branch and occupied much of their time. The Deputy Station Manager expressed the opinion that maintenance work is better done on days than shift for several reasons, i.e. staff are more responsible and work better on days; continuity of work exists on days. By transferring much of the maintenance work to days the shift maintenance staff would feel more willing to undertake defect work knowing that the main maintenance programme was unaffected. Other discussions on the working patterns are covered in Chapter 9..

A Two Station Nuclear Site

The working patterns analysed at this site covered four main parts of the organization. All the tasks of the Administration Department were analysed as were the tasks of a substantial number of the engineers at the site. Three small group studies were carried out plus sundry enquiries into working patterns and problems. Since these latter items were not associated with analyses of the work done they are discussed in Chapter 2 . The main studies at this location were of two Departments, a small one staffed almost entirely by engineers and the larger one by a combination of engineers and industrial staff. These studies will provide the first sub-sections in this Report.

Electrical Maintenance Branch Working Patterns

This Branch performs all the electrical maintenance work on both Stations at the site. The formal organizational structure is shown in Figure A.8 , although this was modified slightly subsequent to the study. As can be seen from the staff tree the Branch work is divided into 'A' Station and 'B' Station Groups, plus a dual Station Shift Maintenance Group. The 'B' Station work required more specialised engineers and was divided into two Sections at this level. Although the Foremen and Fitters are divided



ELECTRICAL MAINTENANCE BRANCH STAFF TREE

FIG A.8

into three day work groups, the two associated with the 'A' and 'B' Stations are normally sub-divided into those working on the nuclear part of the plant and those working on the conventional part. The three Foremen within each of these two groups comprised one for nuclear plant, one for conventional plant and one (the Relief) who covers both. As shown in the Staff Tree, the line of authority goes from Section Heads to the Foremen and not through the other Engineers. The three Foremen dealing with programmes and work shop comprised a Work Shop Foreman, a Works Office Foreman (Planning) and a Relief. The Foremen and Fitters cover a seven day week (hence the Reliefs) and the Engineers work a nominal five day week.

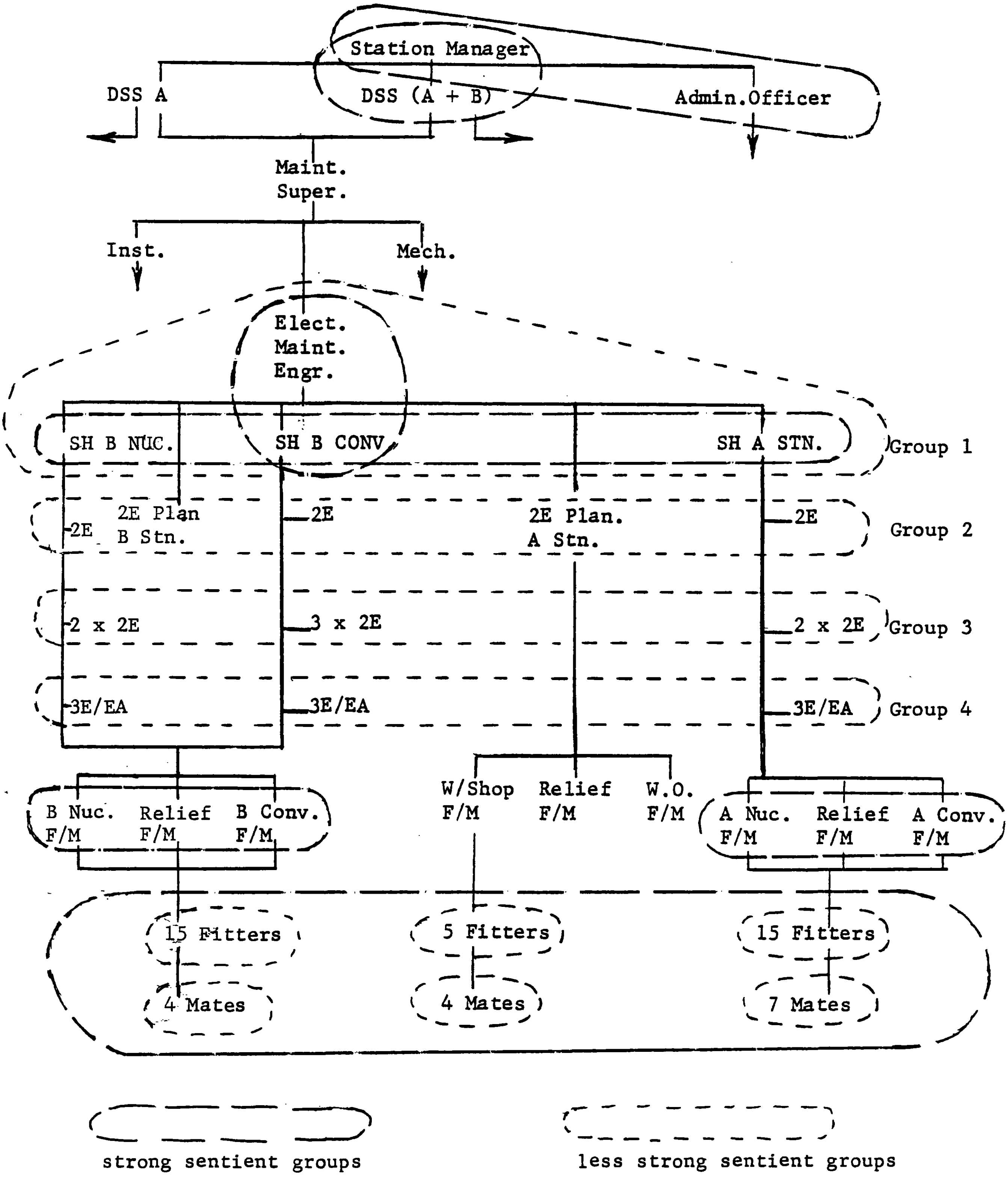
Although the Branch operated to a considerable extent in the manner shown on the Staff Tree, an informal structure existed which is shown in Figure A .9. The groupings shown can be explained as follows:-

The Station Manager has close working groupings with one of his Deputies and the Administrative Officer.

The Maintenance Superintendent had no close groupings within this particular structure. Thus, at this level communications tended to be formalised.

The Electrical Maintenance Engineer had a close grouping with one of the Section Heads who acted as his Deputy.

However, all three Section Heads had a close working grouping and shared an office. Another, less strong, grouping for policy formulation comprised the three Section Heads and the Branch Head. Some of the Second Engineers had seniority in terms of length of service over the others and these formed the loose knit horizontal grouping as shown by the dotted line. The other Second Engineers tended to group in a like manner as did the Engineering Assistants. The three



ELECTRICAL MAINTENANCE BRANCH GROUP STRUCTURE

(not including shift maintenance)

FIG A .9

line Foremen associated with the 'A' and the 'B' Station Sections comprised one dealing with conventional plant, one with nuclear plant and one covering both as a Relief. Each of these two groups formed close internal working and social links. All the Fitters and Mates formed another main grouping within which subsidiary groups existed. The usual separation between Engineers and industrial staff existed, but stronger links between the two might have been formed had the Engineers shared the same building as the industrial staff. Similarly, the links between the Shift Engineers and the Day Engineers might have been stronger had they shared the same building. Much of the organizational structure has been created by the Electrical Maintenance Engineer, as have many of the working patterns and the standards of work. Because the Branch is considered by the rest of the Station to be effective, it is probable that his ideas and wishes have been accepted. Any failures in plant have to be explained by reports and no doubt a series of such failures would result in an investigation by the senior Station Management.

For the Engineering staff (but not the Shift Maintenance Engineers) the total electrical plant on site is divided into appropriate blocks, each of which is allocated to an Engineer. This allocation of plant to Engineers also includes the Section Heads who play a managerial role in ensuring that the short term work programme is carried out effectively and urgent matters are dealt with. Planning and Programming Engineers for each of the Stations spend a great deal of their time facilitating work and co-ordinating their activities with other Maintenance Branches. Each morning a series of Section Meetings are held which are attended by Foremen and Shift Engineers and plant problems are discussed. Urgent matters are dealt with by the Engineer responsible and they will afterwards carry out planned work, inspections of the plant, organizing of supplies and spares and devising modifications and improvements. Some of the Engineering Assistants are classed as technicians and they carry out a routine testing programme of high voltage switchgear. Electrical Engineers probably spend rather more time on the plant carrying out tests than do Mechanical Engineers, although Instrument Engineers have a generally similar work pattern. After having responsibility for a certain plant area for between one and two years, it is usual to transfer the Engineers to another plant area in order to provide more job interest, to broaden the Engineer's experience and to provide a greater technical cover for the plant.

Four of the Foremen in the Branch might be described as Line Foremen with responsibilities for plant areas. A fifth has responsibility for the Work Shop and the work carried out therein. These five Foremen feel a direct responsibility for their areas of plant and the state of that plant. The sense of responsibility is not so great for the Relief Foremen since their dual areas of plant allow them insufficient opportunity to become familiar with any of it. It is also the practice within the Branch to change the Foremens' areas of work from time to time. The Works Office Foreman acts as a clearing house for all the jobs in the planned programme of work, plus the requests from the Planning Engineers for urgent work. The jobs are timed and he has to match the work load to the resources available and also to make the resources available when certain larger plant items are taken off load. Another job is to re-programme outstanding jobs and to drop some of the routine jobs in order to keep the programme generally on time. The largest group of men are the Fitters and Fitters Mates and their work covers a wide range from heavy electrical work of a mechanical nature to electronic work very similar to that carried out by the Instrument Mechanics. The Mates are not supposed to carry out skilled work and whether they do or not depends on the individual Fitter with whom they are working. In most cases the Mates tend to act as a second Fitter under the direction of the actual Fitter. In fact the Foremen carry out some matching of jobs to individuals' abilities and preferences and also try to arrange for continuity of work when possible.

Job descriptions were prepared for all the Engineers and these included an analysis of each task in terms of time spent on management, supervision, engineering and administration. In this study an attempt was made to analyse the engineering work into three types, namely:-

Professional Engineering: defined as the application of engineering theory to the solution of problems.

Technical Engineering: the application of practical experience and knowledge to problems.

Technician Work: the carrying out of routine engineering work on the plant of a type requiring understanding of engineering theory.

The results are set out in Table A.10 and grouped for the four sets of Engineers identified in Figure A.9. The percentages are based on 100% representing the standard working week. The Engineer with a very high percentage regards his work as a major hobby and extends it voluntarily apparently to the benefit of himself and the Board. The first group, comprising Section Heads and the Branch Head, spend approximately a quarter of their time on administration and on management plus supervision. It is interesting to note that two-thirds of the remaining time is spent on technical engineering, presumably making use of their years of acquired power station plant knowledge.

An alternative picture of the work of this group, built-up from the job descriptions, shows them attending meetings for about a quarter of their time and spending over half their time on technical matters, generally in an advisory way or giving decisions. Much of this would be done during visits to the

ELECTRICAL MAINTENANCE

TABLE A.10

ENGINEERING STAFF

Work Analysis

S.T. No.	Total %	M	S	P	TE	T	A	Grade
1	131	38	13	21	36	-	23	S.E.
2	133	12	17	21	54	-	29	1.E
3	187	18	17	39	76	-	37	1.E
4	120	13	9	29	53	-	24	1.E
TOTAL	571	81	56	110	219		113	
Av. (Gp 1)	143	20	14	27	55	-	28	
5	118	-	5	8	55	23	27	2.E
6	113	-	1	8	60	25	19	2.E
7	117	15	11	7	19	-	65	2.E
8	117	3	18	18	51	6	21	2.E
9	110	3	6	-	19	-	82	2.E
TOTAL	575	21	41	41	204	54	214	
Av. (Gp 2)	115	4	8	8	41	11	43	
10	126	2	8	16	53	27	20	2.E
11	107	1	7	14	56	17	12	2.E
12	124	-	7	13	55	22	27	2.E
13	119	-	4	31	52	15	17	2.E
14	118	-	5	14	70	23	6	2.E
15	108	-	8	8	47	12	33	2.E
16	115	-	8	9	48	10	40	2.E
TOTAL	817	3	47	105	381	126	155	
Av. (Gp 3)	117	-	7	15	54	18	22	
18	117	-	13	-	40	45	19	3.E
20	107	-	-	-	13	64	29	E.A.
21	105	-	20	10	20	46	19	3.E
22	118	-	-	6	45	33	34	3.E
23	105	-	6	-	22	54	23	E.A.
24	118	-	-	5	10	51	42	E.A.
TOTAL	670	-	39	21	150	293	166	
Av. (Gp 4)	112	-	7	3	25	49	28	

KEY: M = Management: S = Supervision; P = Professional Engineering
TE = Technical Engineering; T = Technician Work;
A = Administration.

plant, or the Foremen, or when their Section Engineers come to talk over a problem. The administrative matters involve making returns, organizing supplies, or finding alternatives to those wanted. These Engineers spend most of their time out of the offices and are generally found at meetings, in the work shop, or on the plant.

The second group comprise those Engineers who deputise for the Section Heads and carry out some of the routine organizing duties associated with the Sections. The two with very high values for administration are the Programmes Engineers and this pushes up the average level on administration for the group. The other three have working patterns not dissimilar to those of the other Second Engineers. They do spend less time on professional engineering and rather more on technical engineering which would fit in with their longer experience of power station plant.

The two Programmes Engineers are the co-ordinators and troubleshooters within the Branch. They attend planning meetings and check planned work for availability of materials and permits. A great deal of time is spent in the work shops talking over the programmes with the Foremen and the Works Office Foremen. They often visit Stores to check stock, or procurement problems. They slot non-routine jobs into the programme and prepare work card packs for major outages and subsequently co-ordinate the work on major outages. They also work closely with similar Programming Engineers in the other engineering disciplines. The other three Engineers in this group keep in touch with the Section's work since they frequently deputise for the Section Heads. They also carry out a great deal of measurement and testing on certain high voltage plant.

The third group in the Table are the main body of Second Engineers and the averages for this group are reasonably representative of the individuals within it. A very substantial part of their working time is spent on engineering and nearly half is the application of acquired knowledge to the solution of problems. Each Engineer is expected to deal with urgent problems in his plant area, although the work is allocated sufficiently flexibly to ensure that a Section work load is reasonably uniform. A great deal of these Engineers' time is spent on the plant working on the equipment and especially those areas of plant, such as the Control Rod Systems, where a mistake could trip the reactor (an expensive procedure). When fault investigations are more routine these Engineers will raise the work order cards and give technical information to the Fitters if necessary. They also check circuits on completion and prepare test procedures. The organizing of spares or alternatives and the writing of technical reports are the main administrative duties for this group of Engineers.

The final group of Engineers comprise the Third Engineers whose duties are generally similar to those of the Second Engineers, although usually carried out on less important areas of plant since these Engineers often lack plant experience. The Engineering Assistants are classed as Technicians and carry out the series of routine tests on high voltage switchgear in accordance with the programme. Both groups will assist more senior Engineers on tests requiring two persons. The administrative level for these Engineers is higher because they maintain routine records of all the testing carried out.

All the Engineers spend a considerable part of their time alone on the plant, this varying from about one-third for Senior Engineers to over half for the Technicians. The main reasons for this are (a) the complexity of the sequencing and interlock systems and (b) the high voltages of much of the equipment requiring an authorised engineer for the work.

The work loads for the N.J.I.C. staff will be divided into those for Foremen, Fitters and for Mates. Dealing first with the Foremen, one of their important functions is to organize the work which occupies them at various times throughout the day. They have to ensure that all Fitters and Mates are able to start their jobs which means overcoming problems relating to permits, stores, etc. When Fitters are absent, urgent work has to be re-allocated as do urgent tasks arising after the morning meetings with the Engineers. The Foremen frequently use their experience to re-allocate the work in advance of the morning meetings. Several times a day a Line Foreman will visit the plant ensuring that the Fitters are able to get on without any undue trouble and giving advice and encouragement if required. The Fitters expect the Foremen to deal with all problems relating to spares, permits and contacting Engineers. They are also expected to have a greater practical knowledge of the plant than anyone else. During their visits to the plant they carry out inspections and raise job cards for any work they believe needs to be done. Up to a third of the routine work on the plant is generated by the Foremen in this manner. They also organize minor tasks on behalf of Line Foremen from other disciplines, e.g. disconnecting an electric motor. They will carry out some jobs on the plant such as opening switchgear to inspect contacts in order that replacements can be ordered in adequate time.

A major part of their job is dealing with the paper work associated with the Productivity Scheme and planning. These tasks include writing requisitions, checking recommended spares lists, dealing with work order cards and work registers. They also organize the writing of work specifications and check them all through on completion and subsequently file and index them. They work closely with the Works Office Foremen by noting the projected jobs and the likely progress on jobs in hand. They also advise on the preferred men to carry out specific tasks. Another duty for the Foremen is to carry out certain projects on their plant for which they will prepare a scheme and write job cards at the appropriate rate to ensure continuity. One further duty is to act as Good Housekeeping Foreman for an area of plant other than their own.

Analysing the jobs of the Foremen shows that one-third of their time is spent on managerial or supervisory work and rather less than one-third on technical aspects. The other third was spent on administrative matters. A little of their work could be classed as very urgent and another small proportion (projects) would be long term, but the majority of their work is concerned with fairly urgent matters generally required the same day or the next. This pattern of work applies to the four Line Foremen and their two Reliefs. The Work Shop Foreman's pattern of work differs since he seldom visits the plant, nor does he have line responsibility for an area of plant, although the responsibility for Work Shop facilities is commensurate. He deals with some general administrative matters on behalf of all the Foremen, including certain disciplinary procedures such as timekeeping, absences, etc. As a result he spends nearly half his time on administrative matters, less than a quarter on technical aspects, and about one-third on managerial and supervisory matters.

The pattern of work for the Works Office Foreman is entirely different and is almost entirely administrative. The job is essentially one of communication and administration and most of the work is concerned with the following day. It would best be described as a very "busy" job.

For the N.J.I.C. Fitters, their pattern of work is mostly defined and controlled by paper work systems. Jobs are timed and allocated with work order cards and the work required to be done is set down on work specifications. Stores are obtained on requisitions and working hours recorded on time sheets, clock cards and leave forms. The average Fitter was measured as spending about 7% of his time on paper work and over 10% on collecting materials from Stores. About 80% of his time was spent carrying out a variety of jobs, the mix varying from a single job lasting several days, to the short term job which might total ten in one day. Typically, two average size jobs in one day is the working pattern. In theory all the Fitters are supposed to be able to do all the jobs and in practice most of the Fitters cover a wide range of jobs. Some selection takes place by the Foremen to take account of attitudes, experience and preferences and the men can influence this by requesting an opportunity to work on another job. Sometimes a Fitter is left on a certain type of work for a period of time, e.g. installation work for twelve months.

The work ranges from the heavy mechanical type associated with large electric motors to fault finding on electronic circuit boards. A great deal of the work is in the middle range, handling fair sized electric motors or switchgear. A more meaningful division is into routine work and defect work with a certain small amount of installation or modification work.

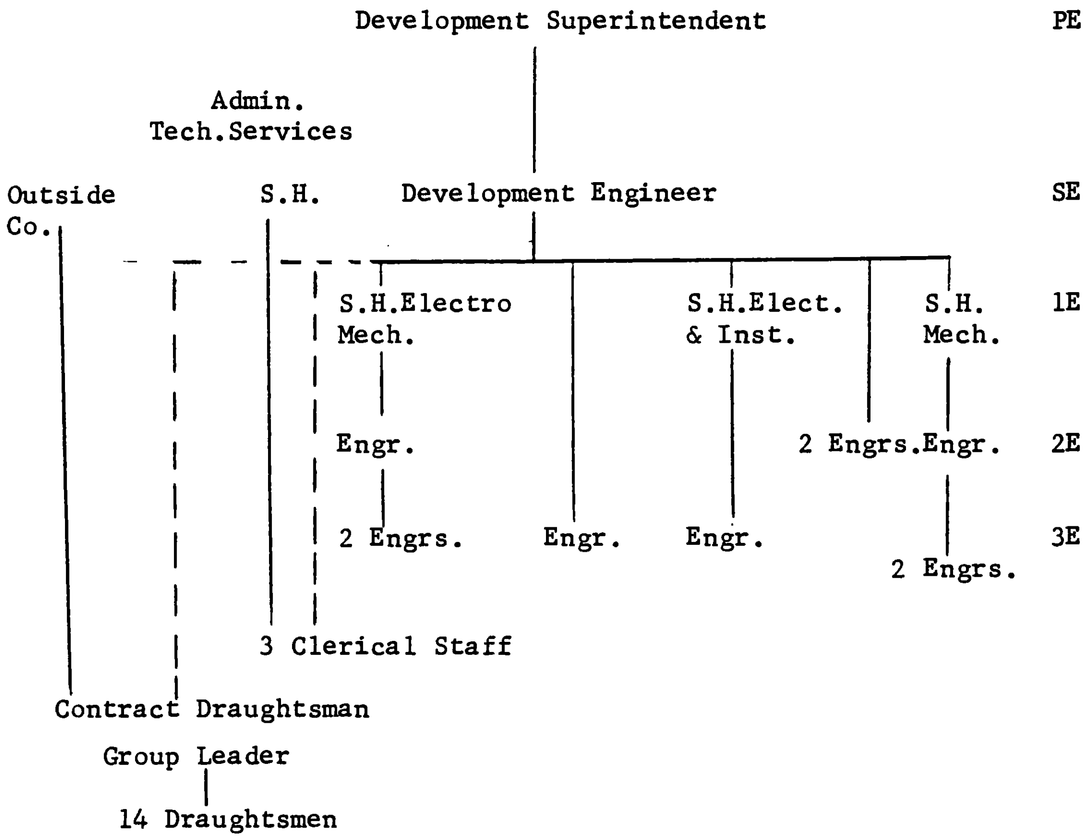
Fitters Mates are normally assigned to those jobs where two men are required. Therefore they normally work with a Fitter who acts as their supervisor. Their duties are intended to be the collection of materials, cleaning components and assisting in dismantling and assembly. On a typical job, the Fitter and his Mate will work together on dismantling, cleaning and re-assembly which occupies the bulk of the time with the Fitter carrying out the skilled tasks, e.g. skimming commutators and also making decisions about the state of contacts, etc. Other jobs for the Mates are the replacing of lamps, moving platforms, ladders, etc. and assisting in general rigging duties which do not justify the use of a Rigger. The checking of batteries is another substantial task for Mates. On many jobs the presence of a second person is required for safety reasons, e.g. at the bottom of a ladder.

A study was made of some of the work totals and working systems within this Branch and they are analysed in Chapter 6 . The opinions of the staff, both in relation to work and other aspects of the location, have been set down in Chapter 6 and summarised in Chapter 9.

The Development Department

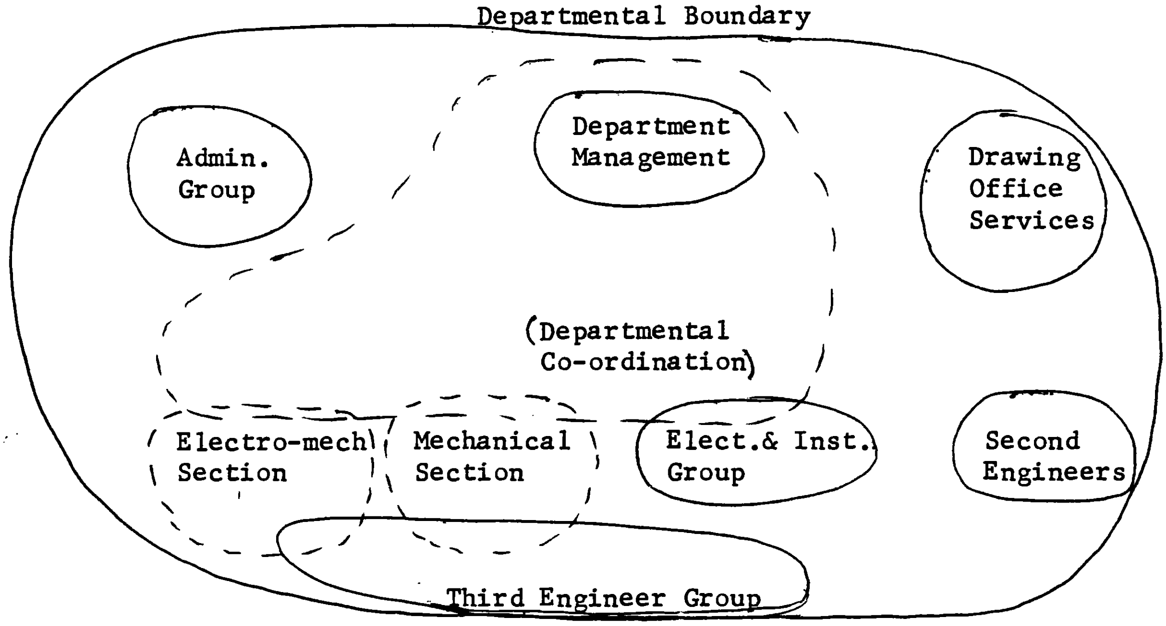
The formal structure of the Development Department is shown in Figure A.11 and comprises three Sections with Section Heads and two Sub-sections without Section Heads.

Figure A.11 - Development Department Staff Tree



As can be seen the clerical staff and Draughtsmen belong to outside organizations even though they permanently and exclusively work for the Development Department. The most important boundary within the Department is the actual Departmental boundary. Other parts of the Station organization regard the Development Department as an enclave outside the main stream of Station affairs. This separateness strengthens the Departmental boundary and contributes something to the weakening of internal boundaries. An attempt at illustrating these internal groupings is given in figure A .12.

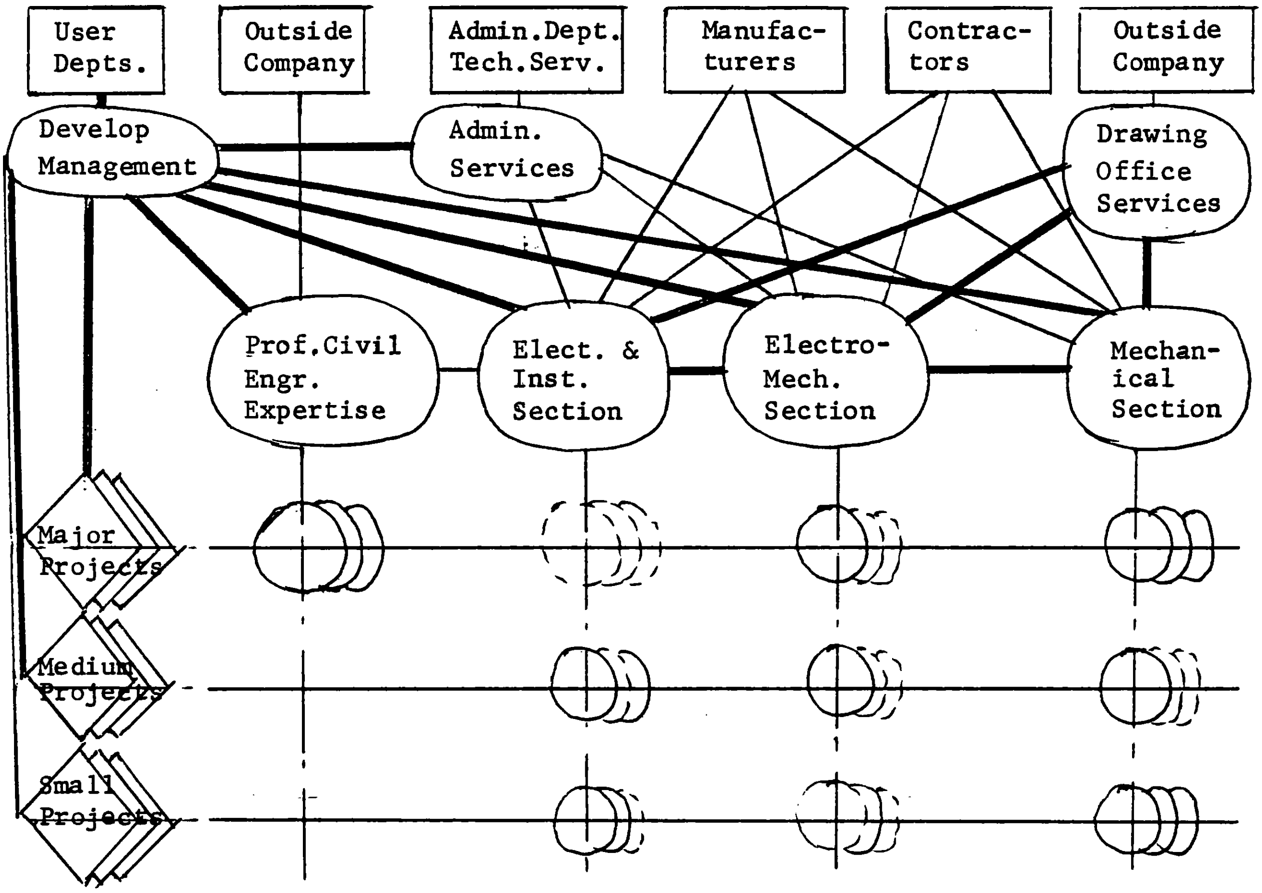
Figure A..12 - Development Department Groupings



The boundary lines are shown as two types, but those for the Electro-mech and Mechanical Sections are not too far removed from the solid lines whereas the solid line for the Third Engineer Group is close to being a dotted line.

Within these frameworks a considerable flexibility of working existed and some individuals in the study claimed to be working on their own, whereas Section Heads told me that they did exercise some organizational control over the work of these individuals. This lack of a clearly defined structure had similarities to those found in certain research organizations studied by Burns and Stalker . The research of Burns and Stalker indicated that such fluid structures were best suited for the management of change and the rate of change within the Development Department is high with projects lasting an average of nine months each. For larger projects involving more than one Engineer the organization becomes a form of matrix and this is illustrated in Figure A.13.

Figure A.13 - Development Department Project Organization



Typical involvement in a project.

Lesser involvement

As can be seen the management of projects (except small ones) is in the hands of the Development Department Management and the primary manpower is provided by the three Sections, plus external civil engineering expertise. These groups make use of secondary services as illustrated in the diagram. Sometimes the involvement in the project is high and at other times it is peripheral and this is particularly so for the Electrical and Instrument Section who seldom carry through major projects on their own. Occasionally a very large project arises and then the Development Department tends to restructure itself around the project and tends to become a single entity with the individuals having "private" interests in minor projects.

The method of working within the Department is relatively uniform since all the work within the Department is of a project nature. The basis of the system is that an individual (or a team for large projects) should carry through the work from the initial recognition of the problem to the final commissioning and handing over of completed equipment. During a project support services will be used and other Engineers are available as consultants. When major projects are handled by a team, certain parts of those projects are subsequently handled by individual Engineers, e.g. the electrical parts. Generally each Engineer in the Department handles three or four projects at once, usually in varying stages of progress. Of these, only one is likely to be of a substantial nature and this would occupy the majority of a post holder's time. Small projects might consist of the supply and installation of a unit of proprietary equipment followed by the testing and handing over of a completed job. With such projects there are periods during which no activity occurs, e.g. waiting for deliveries. The pattern of work gives rise to a sustained steady work flow with occasional peaks when several projects require attention at the same time. For most projects the tempo of work generally increases from start to completion and is often quite intense when the installation stage is reached. Central co-ordination and direction of projects is carried out by the Departmental Superintendent and his Deputy. Progress is monitored by the Deputy. The detailed progress of projects is handled by Section Heads who also act as advisers. A major activity for all the Engineers in the Department is to apply pressure to contractors and suppliers so as to keep work on schedule. They often act as co-ordinators and providers of facilities such as permits, isolations and site services. The largest support service in the Department is the Drawing Office and usually one of its members handles all the drawings associated with a particular project. The Engineers establish and maintain contacts with manufacturers and contractors, excepting in the case of large contracts where negotiations are handled by the Development Superintendent.

A similar analysis of all the tasks for all the Engineers (excepting the Development Superintendent and his Deputy) was carried out and the percentages obtained as averages are shown in Table A.14.

TABLE A.14 ALLOCATION OF TIME

Managerial Activities	3%
Supervisory Duties	17%
Professional Engineering	10%
Technical Engineering	33%
Technician Duties	5%
Administrative	40%
Total	108%

The Department operates efficient administrative procedures such as standard contract conditions and yet 40% of the average Engineer's time is still taken up with administrative work. A substantial proportion of this percentage is spent on organizing and progressing orders and supplies. The ratio of time spent on different forms of engineering is probably a reasonable mixture of experience and applied theory and the comparatively small percentage on technician duties arises because only at the very end of a project is there any plant on which to work. The three percent average for Managerial activities is somewhat misleading, since the average for the Section Heads was 9%. Comments about these working patterns are included in Chapter 6 .

The Administration Department

Job descriptions were prepared for every post in the Administration Department as part of a study leading to a reorganization. Many of the systems and procedures at this location were similar to those described for the coal fired station. This is not surprising because many of these systems are R.H.Q. based. The largest administrative Section was the Technical Records and this arose because of the sheer volume of work associated with the work planning and pay and productivity scheme systems. The Section also provided administration services for the various Engineering Departments. The planning services were a major Sub-section with their own Group Leader and were divided into long term planning procedures and the Works Office (short term). The bulk of the work relates to checking work specifications, preparing work programmes and handling work cards. Also the administration of the P. & P. Scheme is carried out within this Section. Much of the work involves calculations and transferring data to summary sheets. Subsequent to this study much of the work associated with the P. & P. Scheme and work planning was transferred to computers and this led to some reduction in the staff within this group. The Technical Records comprise a smaller group and their function was to carry out a number of calculations on plant performance information obtained from the Test and Efficiency Sections. These included calculations for the government and monitoring of nuclear power stations. Many of these calculations had to be cross checked by a second member of the staff. Another group was concerned with the commissioning of the 'B' Station and provided a progress and monitoring function. This was considered necessary because of the constant slip in commissioning dates and enabled Station Management to apply pressure to the manufacturers and to the Project Group. One small group was concerned with monitoring the work of contractors, particularly those being paid on the basis of time and materials. All delivery notes and clock cards were summarised and checked against the contractors' submitted returns. Nine of the staff were allocated to the various Engineering Departments and their duties varied according to the Department, but most included filing, photo-copying, collating and some typing. Reference manuals would be up-dated and work sheets and maintenance records collated. In some Departments, e.g. Reactor Physics, the clerks were used for technical calculations of a routine nature which released the Engineer for more technical work.

The second largest Administration Section was that entitled Administration and Finance. In addition to these two Sub-Sections, a third existed comprising the Station Warden. If the industrial staff under the control of the Station Warden were included, the 21 Administrative staff would be increased by an additional 62 staff. This sizable Sub-Section is controlled by the Station Warden who is left very much to his own devices. It provides a site security service and a substantial team of Cleaners in addition to Gardeners, Drivers and a Fireman. The Finance Sub-Section is concerned with the preparation of the Capital and Revenue Budgets for the location and with amendments and updatings. All goods receipts and documents are checked and graphs and statistics produced. A Cashier and Assistant handle various cash transactions and have the main responsibility for the preparation of the industrial staff wage packets. Collection of money from the Canteen and loading the slot-machines are other duties. The Administration Sub-Section provides a registry and filing service in addition to despatching mail, dispensing stationery and ensuring that reliefs are available for Telephonists, Receptionists and Private Secretaries. A Typing Supervisor organizes the work of a team of about six Typists allocating and checking work and preparing rotas.

The Stores Section has the two main functions of purchasing and checking stores and providing a stores counter service to the Station. The stores counter service is provided by nineteen industrial staff (six on shift) and the stores administrative service is divided into purchasing and accounting. The stores accounting group have the responsibility for stock checking and for dealing with all enquiries relating to invoices. The routine stock cards and other records are processed by this group. The purchasing group receive requisitions, check them and despatch them and monitor the total ordering process. Contracts records are updated and progress chasing is a continuing function. Stocks are checked regularly to see whether the stock-holding levels need to be adjusted.

The Personnel and Salaries Section comprise the last substantial group of staff in the Administration Department. The Section also includes responsibility for the Canteen which comprises an additional fifteen N.J.I.C. staff. Apart from general guidance and some clerical help with stock-taking and cash receipts the Canteen is self-sufficient. The Personnel Sub-Section is primarily administrative and does not deal with such personnel matters as industrial relations, etc. Organizing advertisements, interviews, appointments and terminations for industrial and some clerical staff are a major source of work. Dealing with local authorities, or housing requirements and the Clerical Work Measurement Scheme are other areas of work. The final major area is keeping records of manpower returns for senior Management and for R.H.Q. The Salaries Sub-Section check the times worked from time sheets against the clock cards. They also keep records of sickness and holidays and any overtime worked. Special allowances and temporary upgradings have to be checked and all these variations entered on the salary input documents. All calculations and entries have to be double checked. Checking the pay slips and making-up the pay are additional duties inevitably followed by dealing with pay queries.

The other administrative posts at the location are the Administrative Officer who provides information for the Station Manager. In addition to generally monitoring the function of all the Sections by the Section Heads he generally deals with non-routine matters. Other special tasks are acting as Secretary to the various committees and dealing with confidential matters. The post holder also deals with some of the site industrial relations. The Computer Section existed for approximately three years, during which time systems were created and programmes written for many ofthe functions at the location. At the end of this period the work was becoming more routine and the remaining duties were transferred to the Planning Department Computer Section.

Timings were estimated for all the tasks of each person in the Administration Department, but a general check on the nature of the duties shows a basic similarity to those of the Administration Department at the coal fired Station. As a result it is fair to conclude that the bulk of the Administration staff are involved in the processing of information relating to the systems. Thus, the study of the systems (Chapter 7) is more rewarding than a study of the tasks of the staff servicing them.

Operations Department

The two Stations on the site each have an Operations Department and each have different working patterns arising from the needs of the plant. The older Station could be described as base load steady state, whereas the newer Station is still commissioning.

The tasks and time allocations for these Operations Engineers are significantly different from those of the other locations and have therefore been presented in Table A.15. There are thirteen day posts associated with Operations and seven shift posts (each multiplied by five). The day posts include a Test & Efficiency Group and some specialist Engineers concerned with the fuel route. On shift two of the Engineers have duties specifically relating to the nuclear aspects. It should also be noted that in nuclear Stations Engineers man the Control Desks, rather than industrial staff.

The Operations engineering posts relating to the newer Station have changed significantly since the job descriptions were prepared and so a summary is given instead of a table. As on the older Station there are seven Engineers on each shift, two of whom are at the Reactor Desks. Only one Engineer is engaged on the fuel route and the other assists the Plant Engineer in solving plant problems, carrying out isolations and organizing permits. The day Operations are divided into two

TABLE A.15: A TWO STATION NUCLEAR SITE

MAGNOX STATION, OPERATIONS DEPARTMENT, NJB POSTS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% ages Total Time)			
					Man.	Sup.	Tech.	Adm.
OA1	PE	Operations Superintendent	To manage and co-ordinate 'A' Station operations activities so as to economically maximise plant availability and meet system and statutory requirements.	Principal roles are Departmental Manager and overall co-ordinator of work. Administrative duties include budgets, forward planning, monitoring and reviewing departmental systems. Dealing with Industrial Relations, authorising training courses, holidays rotas etc. Having technical discussions with staff and giving decisions. Discussing the station policy with the Deputy Station Superintendent, co-ordinating departmental requirements with those of other departments. Monitoring departmental performance, checking state of plant and reading technical data.	30	20	20	30
OA3	SE	Day Operations Engineer	To manage and take responsibility for reactor safety devices and efficient and adequate reactor fuelling.	The post holder has the dual roles of Manager/Co-ordinator and Technical Consultant for the fuel and reactor safety systems. Dealing with all managerial aspects of the supply and disposal of fuel elements. Giving advice and decisions of technical matters relating to the fuel machinery including the pile cap. Dealing with administrative matters, industrial relations and technical report writing. Checking performance and investigating anomalies. Organising and monitoring tests of reactor safety systems.	25	15	40	20
OA5/9	SE	Shift Charge Engineers	To ensure that all plant requirements are met during the shift, take emergency actions and to make managerial decisions.	The post holders are managers of the station outside day working hours. They monitor, supervise, guide and advise staff to ensure satisfactory work progress and correct plant operation. They ensure that all the statutory safety and other requirements are observed by the work force. They make decisions about the plant and vary the working plan whenever necessary. They consider longer term requirements and inform the relevant day staff. They carry administrative functions, technical report reading, reviewing work systems and deal with staff problems in relation to their shift.	20	40	30	10
OA20	1E	Performance and Efficiency Operations Engineer	To monitor plant conditions [illegible]	The main role is that of Plant Performance Expert and Adviser. Supervising, monitoring and dealing with administrative and personnel matters for the Section Staff. Checking measurements, data and investigating anamolous results. Making decisions, arranging additional tests, recommending changes in rating conditions. Discussing findings with power station engineers. Organising special requirements such as special tests.	5	15	40	40

TABLE A.15: A TWO STATION NUCLEAR SITE

MAGNOX STATION, OPERATIONS DEPARTMENT, NJB POSTS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% ages Total Time)			
					Man.	Sup.	Tech.	Adm.
OA21	1E	Fuel Operations Engineer	Improvement of the pond and effluent plant facility.	The Engineer's role is that of being technically responsible for specific areas of plant. Organising, supervising and administering the cleaning up programme for the fuel ponds. This involves supervision of the work, resolving problems and giving technical advice. Dealing with the related problems on the main plant. Carrying out forward planning to ensure steady state operation of the spent nuclear fuel system. Advising the fuel route engineers on shift of the current plant state.	15	25	30	30
OA22	1E	Operations Documentation Engineer	To ensure that plant and station operating instructions are updated, relevent to needs and optimise performance.	The Engineer is an administrative specialist collating technical information about plant. All existing operating instructions are reviewed and revised and this involves discussions with operators, the checking of plant and the organising of tests. Information about operating conditions including test programmes are prepared for new items of plant and subsequently procedures are written. Such procedures involve the preparation of drawings and documents.	5	10	40	45
OA23	1E	Pile Cap Engineer	To ensure Pile Cap equipment is efficient, safe and operated to achieve desired fuelling targets.	The role of the post holder is that of manager and technical expert for two specific items of plant machinery. He provides technical direction and advice and monitors progress on routine work. Problems are investigated and the solutions implemented. Technical information and direction is given to the shift fuelling engineers and results of tests on the machinery are monitored. Daily working plans for the machinery are produced and monitored.	10	20	50	20
OA24	1E	Systems Operations Engineer	To improve the station operational systems and to analyse failures.	The role of the post holder is to investigate and improve certain station operating systems. The systems cover the ~~iodine plant~~; the permit key system; the emergency feed systems and feed control systems. Also authorisation checks and occasional special investigations are carried out. Procedures vary, depending on the system, which is generally enquiries into current working, devising suitable alternatives, contacting manufacturers, suppliers or engineers and implementing improvements and changes are the main stages in such tasks.	0	0	70	30

TABLE A1.15: A TWO STATION NUCLEAR SITE

MAGNOX STATION, OPERATIONS DEPARTMENT, NJB POSTS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% ages Total Time)			
					Man.	Sup.	Tech.	Adm.
OA25/ 29	1E	Assistant Shift Charge Control Engineer	To ensure plant conditions are maintained at station requirement; to take any necessary emergency actions.	The post holder's dual roles are those of general overseer of plant conditions and emergency decision maker. Important control parameters are monitored continuously and continuous supervision of the control room staff is carried out. Emergency decisions are made (only very rarely). Routine grid switching is carried out; routines and plant checks are organised. Acting as a communications centre, general clearing of site requirements, including making decisions and giving instructions.	10	40	35	15
OA32/ 36	1E	Assistant Shift Charge (Plant)	To maximise plant availability and plant safety.	The main role is that of exercising technical supervision of all work on the plant and ensuring that safety and statutory requirements are met. The general checking of the plant state and investigating faults, followed by making technical decisions and giving technical advice is the main work area. Organising isolations, issuing permits, checking work on completion is another major unit of work. General monitoring and supervision of work in progress, discussing priorities with the Shift Maintenance Engineers and Foremen is the other area.	10	30	40	20
OA40	2E	Fuelling Assistant Engineer	To audit and monitor fuel movements on site.	The post holder's main role is that of supervisor of fuel movements. Records are kept of fuel arrivals, use, pile cap movements, fuel into ponds and fuel despatched stages. Continuing station records are kept of this information. Investigating engineering problems associated with the fuel route.	0	20	40	40
OA44/ 48	2E	Assistant Fuel Operations Engineer	To ensure the fuelling system is effective.	That of having special responsibility for the fuel route equipment. Fuelling operations are checked and especially the fuel for loading. Safety and nuclear requirements are monitored in relation to the fuel route and pile cap. General supervision of the pond area including fuel despatch is carried out. Isolations are checked and permits to work issued for items of plant on the fuel route by the post holder.	0	30	40	30
OA50	2E	Assistant Fuelling Engineer	The routine checking of reactor safety systems.	The safety systems test and checking engineer. The tests are carried out in accordance with test schedules and also before recommissioning after maintenance. Organising the availability of plant for testing with the Operations Engineer. The tests of alarms are carried out in accordance with a fixed programme and records are maintained.	0	5	65	30

TABLE A.15: A TWO STATION NUCLEAR SITE

MAGNOX STATION, OPERATIONS DEPARTMENT, NJB POSTS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% ages Total Time)			
					Man.	Sup.	Tech.	Adm.
OA51	2E	Documentation Assistant Engineer	To assist in the preparation of operational instructions for the plant.	The role is that of investigator of existing procedures. The existing operating instructions are reviewed, discussed with the operators and considered for revision. The plant is checked and the drawings and documents for new procedures are prepared.	0	0	50	50
OA53/63	2E	Reactor Desk Engineers	To maximise output consistent with the reactor safety.	The role of each post holder is to drive a reactor. Reactor conditions are monitored continuously and necessary adjustments made. Checks of safety parameters such as temperature and other fault detection equipment. Other routine checks in accordance with operational procedures are carried out and logs are maintained.	0	5	85	10
OA65/69	2E	Assistant Turbines Operations Engineer	To facilitate turbine operation.	The post holders' role is that of supervisor (technical aspects) Turbine and associated plant operation. Faults are investigated, appropriate action decided. Technical supervision of the operations industrial staff is carried out. Plant tests are carried out and isolations checked. Permits to work are issued and completed work checked before the permits are cancelled.	0	30	40	30
OA72/78	2E	Relief Operations Engineers	To provide continuity of staffing of 2E posts.	The role is that of 'stand-in' for the various absences of other shift team members. Reactor desk duties are carried out for about half the time. Turbine Engineer's duties for about 40% of the time. The remainder of time is occupied carrying out short term tasks or receiving training.	0	5	85	10
OA81/86	2E	Shift Fuelling Engineers	To maximise the reactor fuelling process.	The main role is the resolution of short term technical problems on the pile cap machinery. Routine pile cap machinery checks are carried out and general supervision of the operations is undertaken. Technical breakdowns are investigated and solved whenever possible. Work Order Cards are raised when necessary and the work is subsequently monitored. The checking of the safety interlock system is another function of the post holders.	0	10	75	15

TABLE A .15: A TWO STATION NUCLEAR SITE

MAGNOX STATION, OPERATIONS DEPARTMENT, NJB POSTS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	OBJECTIVES	SUMMARY OF TASKS	Nature of Tasks (% ages Total Time)			
					Man.	Sup.	Tech.	Adm.
OA91	3E	Assistant Performance and Efficiency Engineer	The measurement and Monitoring of plant performance.	The role is that of Assistant to the Engineer carrying out measurement on the plant. In addition to taking measurements, the results are analysed and records prepared. New test procddures are devised for special measurement in relation to problem solving.	0	5	75	20
OA92	EA	Engineering Assistant (Performance and Efficiency)	To generally assist in the taking of plant measurements.	Primary role of the post holder is to facilitate the taking of plant measurements. The setting up of test equipment on the plant and the taking of samples are two tasks. For special tests plant operation data is obtained and subsequently recorded and interpreted.	0	0	80	20
OA93	EA	Engineering Assistant (Fuelling)	To assist in monitoring fuel movements on site.	The role is that of technical clerk for fuel movements. records are maintained of fuel arrivals, use of fuel and pile cap movements. Records are also maintained of spent fuel movements into the pond area and to despatch. The shift records are collated with those from the technical records section.	0	0	50	50

Sections, one concerned with the Computer Control System, including the writing of programmes. This group included fifteen Engineers and two industrial staff and their main function was to ensure that all the interlocking control systems were sequenced correctly in order to optimise plant performance and maximise plant safety and security. The other group in Day Operations comprised ten Engineers and their purpose was to test the plant and recommend efficient operating procedures and systems. Engineers specialised in various parts of the plant taking measurements, varying the control system and devising and documenting the preferred procedures and operating conditions. It should be noted that this plant is entirely dependent upon the computer for its operation.

Other Departments Briefly Reviewed

At this location all the other Departments were studied and job descriptions prepared. However, for some of the Departments complete sets of job descriptions were not prepared and for others the results were not analysed in any great depth. The information available is given in the following few paragraphs.

The Planning Department comprised a Works Office which was sub-divided into Sections for each of the Stations. A third of the time of the Section Head was spent in preparing for, or attending, meetings. A similar pattern was reflected in the two Sub-Section Heads. In the latter posts each had responsibility for organizing the duties of the Work Study Assistants (fifteen in all). A major part of the work of the Section was ensuring that all jobs are timed for the Pay & Productivity Scheme. The Long Term Planning Section prepares the work programme for both Stations which involves meetings, discussions and co-ordination with Engineers in most Departments at the location. Another function of this Department was the co-ordination of the commissioning programme for the new Station and a third duty was the direction of the Drawing Office.

Nearly half the Section Head's time was spent in preparing for, or attending meetings. The Section included thirteen Engineers, plus five seconded administration staff. A new Section within the Department was that of Computer Development, the objective of which was to transfer much of the planning function to computer programmes. Much of the work of the Section was creating systems and transferring existing data to them. The other Sections within the Planning Department were a small Work Study Group who carried out work measurement and job timing and a training function. The main function of the Training Engineer was to prepare an annual programme of the training needs of the location and then to subsequently manage this programme in terms of arranging courses, dealing with problems and monitoring progress.

The Station Chemistry Department was a little unusual insofar as the Station Chemist concerned himself with chemistry development work, such as the creation of procedures for the new Station. The Assistant Station Chemist dealt with the routine running of the Laboratory and the work load was divided into five areas, each one covering a type of analysis. These were water chemistry; gas chemistry; oils, ponds and environment; special analyses; duty Chemists (on the plant). As in most Stations a substantial proportion of the work of the Departmental staff was concerned with actual analyses, or the interpretation of results.

The Reactor Physics Department has the function of regulating the loading of the reactors and advising on operating conditions. A proportion of the Department's work is routine, such as the monitoring of reactor conditions and temperatures and the remainder is of a development or advisory nature, particularly in relation to the commissioning of the new Station. A total of fourteen Engineers at different grades comprised the Department and the general pattern of work is to avoid compartmentalisation as much as possible. Routine tasks are allocated at the appropriate levels in the organization, but for a limited period of time. Problems are undertaken by an individual in much the same way as they are handled in the Development Department. Fluid groupings result with ideas and problems being discussed between Engineers and with the Departmental Head.

The Health Physics Department is concerned with nuclear conditions and safety on the site and in the surrounding environment, with the exception of the nuclear reactors themselves. The duties of this Department are much more formalised than those of Reactor Physics, as might be expected with a Department containing 11 Engineers and 131 industrial staff. The work is divided into types and areas and the Department operates such services as the Laundry, the Reactor Area Change Rooms and wash facilities and the plant radioactive monitoring service. The issuing of certificates and the checking of personal exposure meters are other functions carried out by the Department. Other functions of the Department are the periodic checking of the surrounding countryside and monitoring results on behalf of the Ministry.

Working Patterns At A Two Station Coal Site

This study differed from the others because it was a comprehensive investigation into the working patterns and attitudes of all the staff at a large power station site, with the exception of the Administration staff. Over 180 interviews were carried out and these were randomly selected from the various groups on the site. The first part of the information obtained is presented here and relates to the work structure and working patterns, both formal and informal. In this study the organization will be built around its primary function which is to generate electricity. This division of work into core, maintenance, regulatory and improvement functions has been explained in Chapter 5 and it must again be re-emphaised that it is not a division with any official recognition within the organization.

The Core Tasks

The jobs identified as core tasks are set out in Table A.16. As can be seen, they are all shift jobs which is not surprising since the basic parameter of the classification is the time scale in relation to plant needs. All the jobs listed have to be carried out on a 24 hour basis and the list includes all shift jobs with the exception of two, namely Stores and Security. In the Table the duties are outlined and the general comments of the members of the teams are noted. The following comments by the author make some conclusions and draw on some general points made by various individuals in the sets of interviews. The older Station unit crews claim they would be more productive without the Pay & Productivity Scheme and this productivity would manifest itself in higher standards being maintained on the plant with a resultant reduction in the total work load required particularly of the Maintenance groups. The new Station unit crews who are working on commissioned units have a fairly high work load and considered they would be more efficient with better communications. The old Station auxiliary staff say the jobs would be more effectively carried out if the staff were grouped into crews, given responsibility and encouraged to specialise. Similar comments apply to the new Station auxiliary staff and in both cases the total staff numbers were thought to be in excess of requirements. The Operations Engineers for both Stations took the view that much of their work was duplication due to the permits system requirements. They believed that the total permit requirements could be reduced by better organizing of maintenance jobs and also that many of the permits could be signed by the Foremen or operators, particularly when no significant hazards were involved. The Foremen spend more than half their time on paperwork systems mostly associated with the short term planning of work and considered these aspects could be greatly reduced. Furthermore, if the unit operators could regain their status of Chargehands and be able to direct the work of their crews, then another substantial part of the Foremens' duties would be removed.

TABLE A.16 - ASH HAVEN CORE TASKS

R.G.S. Johnston 31.7.1978.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
P.1	A Stn. Unit Crews	Operate & monitor 2 units; isolations.	4S	1UO; 2AUO; 2 APA's.	U.O. adjusts conditions on units, monitors plant. Some organisation and direction of crews work. Mainly in control room. AUO assists UO and inspects plant, takes readings, carries out isolations. (One turbine area, one boilers). APAs (also 1 turbine, 1 boilers) assist AUO with isolations, do plant checks and routines (oil levels, drains).	Some team autonomy, but more before P. & P. Also strong group feeling for A Stn.shift NJIC team. More work under old system, men had pride in own units. Workload varies with system demands - usually moderate. Morale fair, diminished by ageing and untidy plant and no autonomy.
P.2	B Stn. Unit Crews	Share operation & monitoring of 1 unit.	4S	1UO; 1AUO; 2 APS's.	Team operates unit under direction of asst.shift charge engr., for 1 month then moves to another unit. 5 teams, 1 on general plant, 3 on units, 1 on relief. UO checks instrumentation, adjusts plant. AUO mainly on plant, especially turbine, taking readings, making adjustments, carrying out isolations. APA's do similar work to AUO, but on less critical plant (1 boilers, 1 turbines).	Rotation system will be satisfactory when all units operating. Job satisfying when plant operating. High noise levels a problem. Morale higher than A Stn. Sense of belonging to whole shift, stronger in some shifts. Pressure varies very much depending on steady or changing plant conditions.
P.3	A Stn. Auxill-iary Plant	Operate auxill. plant plus ashing, cleaning etc.	4S	1UO; 2AUO; 4 APA's.	Manning plant areas (compressors, aux. boiler house, C.W. plant, demin.) These duties generally to AUO or APA's. No specific UO duties in gp. Aux. plant duties involve checks, isolations and load changes. Most APA's on ashing or cleaning - especially new staff.	Most much preferred previous system of ashing gangs who were permanent and kept plant clean. Also preferred cleaning when related to own units. General discontent with uninteresting work. Work pressure low in general.
P.4	B Stn. Auxill-iary Plant	Operate auxills. plus ashing & cleaning.	4S	1UO; 1AUO; 8 APA's.	The UO & AUO have no specific duties, therefore used for unit standby or doing general work. APA's on water treatment and C.W. plant, etc. Most on ashing or cleaning. Some deployed to maintenance as mates.	Would also like semi permanent teams for ashing. Dislike so much cleaning, especially after others. Think cleaners should do more. Feeling of belonging to main shift team, but no group identity. Several wanted more meaningful work.
P.5	A Stn. Ops. Engrs.	Shift Management; Permits, Investigate plant.	5S	SCE; ASC; [illegible]	SCE & ASC form basis of team, 2 x 2E (plus relief) in team [illegible] then switch to B Stn. SCE. makes decisions balancing plant needs and system requirements. Keeps contact with plant and men, chases day staff for plant needs. ASC supervises plant work and permit system. One 2E in control room - monitoring system controls, passing on requirements to UOs. Other on plant checking isolations; investigating faults; resolving difficulties with SME; recommissioning plant.	SCE & ASC change stations every 2½ years. This liked (ASC could follow SCE sooner). 2E changes too rapid; 1 year better. Many thought permit system overdone. Also that NJIC staff could sign for many permits rather than have engineers checking then signing. 2E's not part of line man which is SCE - ASC - F/M.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
P.6	B Stn. Ops. Engrs.	Shift & plant management; permits, investigations.	5S	SCE; ASC; 2 x 2E.	Similar to A team. SCE & ASC form basis with 2Es more transitory. SCE makes decisions, checks plant, maintains links with men. ASC in control room with direct responsibility for plant operation. (General monitoring of all units). Both 2E's on isolations and permits and resolving plant problems. Also recommissioning plant.	Some 2Es upgrade to ASC, therefore have to cover 6 jobs. (ASC's only do 1 job at time). Shift team social activities vary with team. More involvement with running plant than on A Stn. Better if engineers and men (including Foremen) on same rota.
P.7	Operations Foremen	Supervising, clerical work, planning.	4S	4 F/M.	Cover both stations. One on line in each. Duties are supervising men (mainly the ancilliary teams); checking plant and raising job cards for work to be done. One on short term planning is mostly concerned with matching work to staff available and slotting in urgent jobs. Long term planning F/M works days (3 in). Plan work for major outages. Job mostly clerical. Fifth F/M is relief for others.	Most F/M think the admin does not need F/M abilities (3/4 of time). In general line F/M cover routine work needs of plant. Thought it better if men and F/M and engineers on same rota. Spending 2 months on each job is not satisfactory.
P.8	Mechanical Shift Team	Repairing defects, plus routine work.	4S	1 F/M; 13 NJIC (Craftsmen & Mates).	Team subdivided into A & B Stn. groups. F/M covers both. About half work dealing with short term breakdowns, other half with routine P.M. F/M uses discretion in altering work programme.	Strong team spirit with sub group belonging to whole. Also community feeling with other shift maintenance groups. F/M included. Work more interesting than day work.
P.9	Electrical Shift Team	Repairing defects, plus routine work.	4S	1 F/M; 6 Fitters + 1 Mate.	Foreman reorganises routine work to fit in defects when required. Men in 2 sub groups for each station. Expected to use more initiative on problems than are day staff.	Strong team spirit within total group. (F/M inc). Co-operate with other shift maintenance, but socially separate. Work interesting.
P.10	[illegible] Shift Mechanics	Repairing defects, doing routine work.	4S	3 Mechs. + 1 Mate.	Nearly all work on B Stn. Only deal with urgent items on A. Need to use discretion on what jobs to do. Much of work is defects (nearly half); rest is routines plus maintenance.	Shift duties preferred to day duties - but not shift hours. Defect work most enjoyed. Also greater sense of responsibility. Shift work requires more plant knowledge. Strong team spirit.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
P.11	Shift Maint. Engineers	Solving technical problems	5S	2 x 2E	One mechanical and tends to cover A Stn. mainly. Other elect. and inst. and tends to cover B Stn. Will generally monitor progress and supervise work and organise changes in conjunction with operations engineers. Investigating technical problems and dealing with planning/admin. takes half time.	Work as a team, strong social links. Work challenging and able to use initiative. But carry far more responsibility than day 2E's. Sometimes are blamed by ops. engineers for day maintenance failings.
P.12	Coal Gang.	Receiving coal, filling bunkers.	4S	2 F/M; 2 controllers; 5 drivers; 11 conveyor ops.	All work same rota. With 2 F/M, one does control room organising work, deals with problems and liaison with handling engineer. Plant F/M supervises work, visits plant, fills in log sheets etc. Both resolve problems with ops. engineers. Controller monitors flows in system and switches plant in/out, (other is relief). Drivers handle special plant (bulldozers, etc.). Men generally stick to one item. Conveyor operators have 4 sets of duties (2 sets bunkers; conveyors; general duties), these duties changed monthly. Finally 2 samplers take and reduce coal samples (by hand) plus oil samples. All coal gang have responsibility for cleaning 1/4 total plant.	F/M socially a bit separate from men, form small sub group. Team spirit very strong - even includes maintenance fitters. Outside activities usually include F/M. Men help each other out. Morale generally good. Some jobs lonely - e.g. bucket wheel. Discharging oil trains dirty and smelly. Also some parts of plant very dusty and cold. Dust is a health hazard (c.f. coal mines). Older men given lighter tasks. F/M say dirty jobs handed out evenly. Much of work due to plant inadequacies (bunker trimming, spillage, sampling). Most preferred 2 shifting to present 3.

The Mechanical and Electrical Shift Maintenance Teams were comparatively small and spent about half their time dealing with breakdowns which was their main function. Routine, non-essential work was provided for "in fill". Because of a general dislike of shift working (Chapter 10) it might be desirable to reduce the size of the Mechanical and Electrical Teams, but the Instrument Team already appeared to be at the minimum operating strength. The Shift Maintenance Engineers appeared to be fully loaded with technical problems, although the planning and administrative aspects took half their time. Thus, a simplification of the regulatory systems in a power station might ease their work load. One of the less welcome tasks they had to carry out was acting as a "go between" between the Operations Engineers and the Day Maintenance staff. Generally, urgent engineering problems occurred with electrical or instrument plant rather than the mechanical plant and these are the fields in a power station where more specialised engineering knowledge is required. Thus, a more effective Shift Team might have been one Instrument and one Electrical Engineer on each shift, one covering each station. A desire for such support staff was expressed by some of the Instrument Mechanics and a need for adequate cover (a sixth crew) was seen to be justified.

The Coal Gang found themselves working full shifts mainly due to various shortfalls in the plant. The plant was originally designed with bunkers having a 12 hour capacity and with fully automatic sampling equipment. This should have resulted in two shift operation. In the event, the new station bunkers suffer from "pipe-flow" in which the only "live" coal is a plug the height of the bunker and approximately six feet in diameter. Most of the coal sampling was apparently done by hand and a substantial part of the Coal Gang duties was clearing up spillage, most of which should never have occurred in a well designed plant. Thus, the Coal Gang had to include additional staff to cover three shift operation plus adequate staff for hand sampling (two men per shift) and clearing up spillage (about half the time of the Conveyor Operators).

System Maintenance Tasks

The tasks included in this Section are outlined in Table A.17 and are the remaining tasks which could be classed as vital to the operation of the plant, but, for all of which, delays of up to 12 hours are acceptable. This division is not absolute because much of the work of the Maintenance Engineers could be considered as a support function and a 24 hour service was required for Storekeepers even though in practice this was only available for very urgent matters. The main concern of the Ash Plant Crew was to dump the ash from the short term storage systems before these over filled. Thus, their main duty was driving a fleet of trucks with additional staff operating cranes, bagging plant, bulldozer, etc.

The Storekeeping system was criticised fairly universally by the station staff and the main point of this criticism was that an inadequate service was provided. This implied that more Storekeepers were required, particularly at peak times and a 24 hour service was needed, particularly on the new station. There seemed to be no reason (other than tradition) why such additional Storekeepers should not carry out routine clerical duties during quiet periods on the shift. The most important function was to reduce the waiting time (and frustration) of the Maintenance staff, the cost of which was greater than the additional costs of a better Stores service.

The Mechanical Fitters on both stations had working patterns which included a degree of specialisation. The opinion was expressed that a much cleaner plant would have materially reduced the work load and also would have made the work more pleasant. Further, if the housekeeping standards on the plant were improved, much of the defect work would not have occurred due to the ability of staff to hear and see incipient failures. Also, if plant responsibility was given back to individuals in the Operations Department it was considered this would increase the pride in the plant, increase the number of minor preventative tasks (e.g. tightening of glands) and reduce the number of plant failures. Many also expressed

TABLE A.17 - ASH HAVEN SYSTEM MAINTENANCE TASKS

R.G.S. Johnston 1.8.1978.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
B.1	Ash Plant F/M	Organise and supervise ash plant work.	7D	1 F/M	Two F/M share duty covering work between them. Do not form group. Supervising and clerical organising of ash crew. Much of job is determining number of units to be deployed.	Are separate from rest of ash gang. Duties will overlap about 1/2 days per week.
B.2	Ash Plant Crew	Operate the various ash disposal systems	7D	14 dvrs. APA's	On any day at least 2 teams of 7 men in. Most are drivers. Main duty is driving large ash trucks to tip (10 men/day on average). Other jobs are operating ash cranes, emptying silos and operating bagging plant, using bulldozer. Also regular service of trucks.	Strong team spirit amongst 28 men. Does not extend much outside work. Operating silos tends to go to older men. Very few operate the bulldozer. Bagging is dirty and not liked.
B.3	Storekeepers	Provide a continuous materials supply service	4S + 7D	2S + 1 Asst.S; 1 F/M; 3 S/kprs. 2 Asst. S/kprs.	On shift are 2 storekeepers + 1 Assistant; add day staff of 2 (on average). These run 'A' Station store. 'B' store has average of 3 staff on duty (days only). Issuing tools is separate on 'B' Stn., other duty is general issues. On 'A' Station usually 3 in store (including tools) and 2 on goods in. 'A' store closes at night and storekeeper does stocktaking.	Friendly group with shift and day staff intermixing. Duties generally shared to suit individuals. Need to use index system with 20,000 items. Tools issues slow work on 'B'. Some basic clerical work with stores duties (issue notes, invoice checking).
B.4	'A' Station Mechanical Maintenance	Preventative & breakdown maintenance of 'A' Station mechanical plant	7D	18 to 27 Craftsmen including 2/3 Mates	Sub-divided into boiler and turbine groups and small group of welders. Further specialisation within sub-groups. Much of work is dismantling items (pumps, valves, fans, etc.), refitting and reassembly. Day staff tend to handle major breakdowns. Riggers mostly deal with handling. Mates work with Fitters.	Should be more interchange from turbine to boiler work. Welders want more Class 1 work (done by contractors). Many want more responsibility to decide plant needs and to see jobs through. Working pressure too low. Used to have plant area responsibility - preferred that.
B.5	'B' Station Mechanical Maintenance	Preventative & breakdown maintenance on 'B'	7D	Average of 24 Craftsmen and Mates	Similar sub-divisions to 'A' Station. Work also similar, but more 'in situ' due to larger units. Less team spirit than on shift.	Sometimes allowed flexibility of standards by F/M e.g. 'quick job'; or 'good job'. (Both outside P. & P.) Too much time spent on administrative aspects (stores, job cards, etc). Plant very dirty.
B.6	'A' Station Electrical Maintenance Group	Maintaining & repairing electrical [illegible] 'A' Station	7D	About 10 men on average	Maintenance work on electrical equipment is 3/4 mechanical. Many items large and dirty. Some specialising especially of certain mechanical items. Much of work is dismantling, cleaning, checking, replacing bearings, etc., and reassembly. Remaining work is electrical fault finding [illegible]	Many men prefer mechanical type work, but some the fault finding. None liked the dirt. Contractors do most installation work, many men prefer it to other types of work (more challenging).

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
B.7	'B' Station Electrical Maintenance Group	Maintenance on 'B' Station	7D	About 14 on average	On 'B' Station about 1/3rd is wiring, fault finding etc. and 2/3rds the mechanical type work. Some specialisation, less than on 'A'. Not much electronic type work. Most jobs last less than a day.	Men in shop form a team, but not as strong as shift teams. Reasonable spread of work in general. Too much time on admin. aspects. Mens'work preferences a reasonable match with plant requirements.
B.8	'A' Station Instrument Maintenance Group	'A' Station Instrument Maintenance	7D	About 10 on average	Series of routine checks by 1 or 2 mechs. (in turn). Remainder is routines and defects. Half work is true inst. mechs. work, rest mech. or semi-skilled. About half work done on plant, half in work shop. Jobs vary from half an hour to two days (or more).	Most I.M.'s have preference for true instrument work and electronics. Believed mech. aspects should be done by mechanical maintenance. Work pressure high due to staff shortage.
B.9	'B' Station Instrument Maintenance Group	Maintenance work on inst.	7D	Average about 10	Similar to 'A' Station. Jobs from half an hour to one week. Over half on plant, half in shop. Most of work is overhaul in nature. One continuing job is feed heater controls. Inst. checks by mates on shift.	Some would like more specialisation, others would not. All would like reduction in mechanical aspects. Some thought too much preventative maintenance carried out. Suggested that more mates would ease workload and reduce contractors.
B.10	'A' Station Mechanical Maintenance F/M	Supervising 'A' mech. maint.work	7D	Average 6 per day	Two in works office, evaluating defects, producing cards, slotting into system with PM's. F/M knows which jobs have to be done in sequence and sets up right packs. Line duties comprise supervision of men, dealing with technical problems. Also raising job cards and allocating jobs to men.	F/M used to decide work priorities, now mostly done by Planning Engineers. Much of present work has high clerical content, not satisfying. Would prefer return to traditional F/M role and plant responsibility to men.
B.11	'B' Station Mechanical Maintenance F/M	Organise and supervise work	7D	5 F/M	Work patterns similar to 'A' Station. F/M cover works office and prepare schedules, cards etc. Line F/M cover turbines and boiler groups and workshops. Allocate work, raise job cards, monitor work, maintain good human relations etc. Clerical content fairly high.	Similar views to 'A' Station F/M. - frustration with systems and desire for more direct involvement and decision-making on the plant.
B.12	'A' Station Electrical F/M	Organise and supervise work	7D	Average of 3 per day	Similar general division into works office and line duties. Line F/M allocates work and supervises it. Also advises and checks plant. Raises job cards. W.O. F/M slots in defects with routines and produces daily work sheet and W.O. cards. Also long term planning aspects.	Work generally interesting, but system too confining.
B.13	'B' Station Electrical F/M	Organise and Supervise work	7D	Average of 3 per day	Same general distribution of duties. The W.O. duty includes long term planning aspects, i.e. bar charts and pre-prints of jobs. When 'on line' will visit all fitters during day.	As with others, about 2/3rds of total duties are clerical and administrative. Getting too far removed from man supervision and organisation - the traditional role.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
B.14	'A' Station Instrument Foreman	Organise and Supervise work	7D	Av. of 2/3 per day	W.O. F/M produces plan in conjunction with line F/M who monitors work. Because of high staff turnover line F/M gives lot of technical advice. Also helps mechanics with obtaining stores, etc. Another F/M covers long term planning. Fourth is workshop line F/M, monitors progress in shop, organises stores, permits etc. Generally both line jobs covered by one F/M and both W.O. by one.	Social links at work and some outside. Jobs changed every six months. Generally only 2 in all through the summer so all 'line' and all works office duties by one person.
B.15	'B' Station Instrument Foreman	Organise and Supervise work	7D	Av. of 2/3 per day	1 F/M covering W.O. duties. 2 on line (workshop and plant). 1 on No. 9 team. Also 2 temp. F/M, one on No. 8 annual overhaul (similar to long term planning duty); 1 on work specification writing.	Similar comments to 'A' Station, but less team spirit with men.
B.16	'A' Station Mech. Maint. Engineers	Managing mech. maint., solving technical problems	5D	4 Engrs. 1 SE; 1 1E; 2 x 3E	Both senior members permanent, junior ones rotate jobs. Senior ones do most organising, contracts, spares, etc. Junior engrs., spend more time on technical matters. On average nearly ½ time on admin. spares, contracts, etc., 1/4 on organising and over 1/4 on technical aspects. No plant specialisation by group.	Group is social unit at work. Problems allocated by SE. Some short, some last several days.
B.17	'B' Station Mech.Maint. Engineers	Managing mech. maint., solving technical problems	5D	4 Engrs. 1 SE; 1 1E; 1 2E; 1 3E	Engrs. allocated plant areas (3E assists the SE (boilers) or 1E (turbines)). Technical problems can be minor plant improvements or short term plant problems. Much of work is organising solutions, raising contracts, supervising contract work, chasing supplies, etc.	The four form a social group at work.
B.18	'A' Station Elect.Maint. Engineers	Managing elect. maint., solving technical problems	5D	4 Engrs. 1 SE; 1 1E; 1 2E; 1 3E	Similar pattern to the mechanical branch. Investigating faults, carrying out minor projects, dealing with admin. aspects., organising resources with planning. Some time spent doing elect. investigations and tests on plant.	Strong group spirit as for other groups. Nearly half time on technical aspects is general for group.
B.19	'B' Station Elect.Maint. Engineers	Managing elect. maint., resolving technical problems	5D	4 Engrs. 1 SE; 1 1E; 1 2E; 1 3E	Engineers have plant areas which they cover. Will investigate faults, raise work order cards and organise resources through planning. An average of half time spent on plant by group, more by juniors.	Group spirit exists. More involvement with plant than most engineers (complex plant, sequencing etc.).

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
B.20	'A' Station Instrument Maint.Engrs.	Managing inst.maint. resolving technical problems	5D	3 Engrs. 1 SE; 1 1E; 1 3E	The two permanent engineers spend much of their time organising and doing admin. aspects of work, including decisions about technical problems. Junior engineer much more involved in technical aspects such as designing new instrumentation.	Strong group feeling and fairly close links with rest of instrument branch
B.21	'B' Station Instrument Maint.Engrs.	Managing inst.maint. resolving technical problems	5D	4 Engrs. 1 SE; 1 1E; 1 2E; 1 3E	Making decisions about plant needs (a.m. meeting). Organising work of branch (through F/M). Modifying planned programme. Dealing with industrial relations. Technical investigations about 1/3rd time (1/2 for junior staff). Organising spares, resources, etc. and general admin. is about 1/3rd for most staff.	Team spirit exists. Does not include N.J.I.C. staff.
B.22	Chemistry Branch	Chemical monitoring of plant and materials	5D	10 Chems. 1 SE; 1 1E; 5 x 2E; 3 x 3E; 3 Lab. Techs.	The whole form a coherent group with 4 sub groups within it. Station Chemist and Assistant run group dealing with problems, making decisions, attending station meetings. Another sub group are two plant Chemists. About 1/4 time on analysis, rest discussing technical matters with operations engineers and giving advice. Next group are 6 Chemists doing 6 different sets of analyses in a monthly rotation. Most of time spent on analyses. The 3 Lab. Techns. carry out routine analyses on water and coal and sometimes assist the 6 Chemists.	Stable fairly close knit group. Apart from 2 plant Chemists they tend to be separate from most of rest of organisation. Plant Chemists have most varied job. The 8 Chemists provide weekend cover for water analyses.
B.23	Boiler Cleaners	Internal boiler cleaning	7D	7/8 NJIC Boiler Cleaners	When boiler comes off load cleaners go in and remove dust and scale. Often working from staging or suspended platform in hot and dirty boiler. When boilers all on load (about 1/3rd time) they will do external boiler cleaning and sometimes act as mates.	Work pattern different from others. Men in 3 groups and 2 in on any day (7 or 8 men). Total team of 11 so very close knit with some outside social contact. F/M associated with group arranges many services for them. Better if men on a standby system.

the view that the total work load would be reduced if they were allowed to exercise discretion on the amount of work necessary on a plant unit, rather than carry out the total number of items which were specified on a job card. Several Riggers pointed out that their jobs were often better carried out in parallel, e.g. start a big job, do a small job while waiting for the next stage on the big job, go back and finish the big job. Instead, their work was normally planned as a number of jobs in a series which meant they spent a lot of time hanging around, or carrying out unofficial jobs which had escaped the planning system. The Welders maintained that their work would have been more efficient if they were given permanently deployed Mates, since well over half their time was spent moving equipment around the site and making preparations to weld. They also implied that a large part of their welding work was indirectly caused by poor housekeeping, e.g. jobs such as cutting off bolts. The view was often expressed that more work could be done without the constraints of the Productivity Scheme, by raising station morale and by engendering greater pride in the plant. The increased production would enable the site to operate with fewer Contractors.

Many of the Electrical Fitters stated that between two-thirds and three-quarters of their work was mechanical in nature and at least some of this should be carried out by the Mechanical Maintenance Branch. The opinion was expressed that much of the preventative maintenance work was unnecessary and wasteful. They believed that a more flexible approach should have been adopted enabling Fitters to make technical decisions, e.g. whether the bearings in a dismantled electric motor needed replacement. Much of the more interesting work within the Branch was done by Contractors which gave rise to some discontent. Other causes of frustration were the inadequate Stores system and the excess of paperwork. Several said that competent Electrical Fitters were capable of doing part of the work presently done by Electrical Engineers.

The Instrument Mechanics on both stations expressed the view that a quarter of their work was mechanical in nature and should have been done by the Mechanical Branch. Another quarter of their work could have been done by Instrument Mates with less skills than the Mechanics. Such changes would have enabled the Mechanics to maintain higher standards on the instrumentation and possibly take over some of the installation work being done by Contractors.

Most of the Foremen expressed the view that over two-thirds of their work was on tasks which they considered to be not proper Foremens' duties. Some of the Foremens' traditional role had been taken over by the planning system e.g. determining short term priorities, and this duty, together with a small proportion of the supervisory duties they at present carried out, would occupy them for about half their time. Thus, a dismantling of some of the systems, plus a return to delegated responsibility for Fitters and the possible creation of Chargehands should enable the Foremen staffing levels to be reduced by about half. Even if the present systems are continued the Foremens' involvement could be substantially reduced by the provision of clerical staff. Most Foremen would welcome such changes (assuming staff reductions by natural wastage). A surprising number of Fitters, Unit Operators, etc., expressed no desire to become Foremen with the present patterns of duty.

The Engineers' duties could roughly be divided into two groups, namely those carried out by the "permanent" members of each Branch, and those duties carried out by the peripatetic Engineers. With one exception each Branch is comprised of four Engineers, two in each group. The Engineers associated with the new station tended to specialise, each Engineer taking a plant area. On the old station each Engineer tended to take on tasks in accordance with his current commitments and experience. For junior Engineers about half their time was spent dealing with technical problems on the plant and for the two permanent Engineers about a third of their time was spent organizing work for the Branch generally in conjunction with the Foremen. These organizing duties comprised the management function in relation to each Branch. Much of the remaining time (a half for junior Engineers, a third for senior ones) was spent obtaining materials and services, or "chasing" progress on those already committed. Such duties included the preparation of specifications, etc., for minor contracts. According to comments by others, a greater delegation of authority, allowing Fitters to do some "engineering" tasks and a reduction in their involvement with administrative procedures would enable a smaller number of Engineers to devote the whole of their time to engineering, or management functions.

The Chemistry Branch comprised a group of Chemists and Assistants most of whom spent the majority of their time carrying out various forms of chemical analyses, collecting samples, etc. Much of the analysis was routine in nature and in some power stations these had been fully automated. The two senior Chemists formulated policy and ran the Branch and the two less senior Chemists spent much of their time in interpreting results and advising the Operations Engineers accordingly. The Chemistry Branch deploy specialist skills and have working patterns which differ greatly from any others on the site and to some extent this sets them apart.

The Boiler Cleaners were another support service for the Maintenance Branches because their work is always urgently required when a boiler comes off load and has to be done before any other work can commence. Their "natural" working pattern is to work extremely hard and under high pressure when a need arises and at other times to be on "tick over" with a series of fill in jobs. Unfortunately, the Productivity Scheme precludes such working patterns with the result that the time required to prepare a boiler for maintenance is now considerably longer than it was before the Scheme.

Regulatory Tasks

These tasks are set out in Table A.18 and comprised the majority of the station staff, with the exception of the Operations and Maintenance Departments. All the administration services would have been included in this group had they been analysed in this study. Although none of the tasks were strictly necessary for the operation of the plant it is without doubt that some of the duties would have been carried out by the core and maintenance groups if no regulatory groups existed, e.g. some cleaning. The inclusion of the Administration services might seem surprising but many large American Power Stations operate with virtually no administration services on site and with no Canteen.

The Test & Efficiency group took measurements and obtained data about the plant which were used for monitoring its performance. This enabled Operations and Maintenance staff to make more effective technical decisions. The Section Head spent most of his time on administrative aspects which included some management, but the rest of the staff spent most of their time on the plant preparing for, or taking, measurements. The First Engineers spent half their time in the office analysing the results and interpreting the data. They expressed the belief that the service could have been extended to some extent to the benefit of the station as a whole.

The Labourers provided a substantial workforce on the site which, according to the comments of several people, was not always well directed. Some of the duties were the provision of specialist services, e.g. mobile pumps and many were engaged in the heavier cleaning jobs, such as removing rubbish, etc. According to several comments (by some of the Labourers) the timings for much of the work were over-generous and therefore this group could have been greatly reduced in size without any loss in effectiveness, or, alternatively, could have been used to reduce the contractor involvement on site.

TABLE A.18 - ASH HAVEN REGULATORY TASKS

R.G.S. Johnston 2.8.1978.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
S.1	Test and Efficiency	Monitor plant performance	5D	1 SE; 2 x 1E; 2 x 2E; 1 EA	Team sub-divided into 2 groups. Section Head association with 'B' Station group. Spends time on admin. aspects and arranging more routine work. Also S.H. spends time on plant. The 1 E's do most of results analysis and preparation of data, but spend about half time on plant. The 2E's (& AE) spend about 3/4 time on plant. Much of work is routine plant measurements (pressure readings, vibration monitoring, etc.). Service routines (e.g. condenser leak tests) carried out when required.	Social links within sub-groups. Main frustration is members being constantly seconded for other duties therefore necessary work does not get done.
S.2	Labourers	Wide range of support activities	7D	About 15	Variety of tasks. Generally formed into sub-groups covering areas of work. Some have part time driving duties. One group man the mobile pumps. Many on cleaning jobs usually of a more routine type. Unloading trucks and carting rubbish are other duties.	Some are permanent labourers, but most expect to become mates or APA's. Social sub-groups form at work. Much of the work considered to be boring, but other members had interesting jobs.
S.3	Cleaners	Routine cleaning duties	7D	About 20	Some cleaners have regular duties of semi-permanent nature, e.g. an amenity block (change room, toilets). Each will cover about 3 units. Others form groups moving to different areas and cleaning them for a shift then moving on. Regular cleaners organise minor maintenance in their blocks.	Older men tend to get regular jobs. Some strong social links form within groups. Most would prefer regular areas. Regulars dislike lower standards during their days off. Several thought work pressure too low.
S.4	Drivers	Operating special equipment & regular journeys	7D	3 Class 1 plus 3 Class B	Outside drivers do regular tanker runs in the main. Inside drivers operate variety of plant (skip transporters, fork lifts, cranes). Frequently provide service at short notice for small jobs.	Work system by-passes P. & P. and planning to large extent because requirements often at short notice.
S.5	Transport Fitters	Vehicle maintenance	7D	1 F/M; 5 Ftrs.; 1 Mate	On some days both teams in thus doubling the staff. Individual fitters tend to specialise on particular vehicles. All levels of maintenance carried out on vehicles. Most jobs completed in a day.	Team spirit good and includes F/M. Some dislike of work specialisation. Difficulty due to inability of Fitters to test HGV's. (no licence).
S.6	Security Guards	Monitoring on/off site movements	4S	3 Guards	[illegible] Duties overlap for continuity. One duty is always the gatehouse and one on traffic control during day hours. After hours this becomes a foot patrol. The other duty is landrover patrol around site. No set pattern used.	Each group forms tight social unit. Duties shared by mutual arrangement.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
S.7	Building Maintenance	Routine building maintenance & minor modifications	7D	1 F/M + 10 Craftsmen	Two groups and both may be in on same day. Duties typical for painters, carpenters, etc., in relation to building maintenance. Most jobs tend to be small except decorating. Contractors used for larger maintenance work including decorating.	Group being formed, workshop being built. Original members not happy with new group.
S.8	Site Services F/M	Organising work	7D	6 F/M in each group	Six F/M cover boiler and general cleaners; 2 each for transport and building and 1 W.O. F/M plus 1 Station Warden. Services are operated as a group for W.O. purposes and 2 will be on these duties plus the permanent W.O. F/M. Duties are usual scheduling, allocating and slotting of jobs. Remaining F/M have line duties. Building F/M acts as Clerk of Works on some jobs. Other line F/M spend most time on plant investigating defects, raising job cards, allocating men to tasks, etc.	The group is not a coherent one except for those F/M on W.O. duties. Others will be in own areas of work and likely to associate with rest of work group.
S.9	Departmental Heads	Manage Departments, deal with disputes	5D	5 PE's	No coherent group exists as such. Some more involved with Station Management than others. Some working together by individuals. Most are only slightly involved in technical matters and spend most time on administrative matters, budgets, reading and writing data. Over 1/3rd time spent on industrial relations and staff matters. Co-ordination of inter-departmental activities occupies most of remaining time.	Not much involved in general Station affairs. Some variations e.g. No.9 Commissioning Engineer much more involved with technical aspects.
S.10	Senior Management	Policy direction on Station	5D	1 NJM; 1 PE	Policy discussed jointly with certain areas being covered by each. Station Manager not concerned with Departmental matters except when policy involved. Committees and meetings occupy large part of time. The Deputy is more concerned with co-ordinating work on Station (especially 'B' Station). Has more contacts with other Departmental Heads.	
S.11	'A' Stn. Planning	Co-ordn. of work; preparation of outage plans	5D	9 Engrs. 1 SE; 2 x 1E; 4 x 2E; 2 x 3E	The Planning Engineer and Long Term Planning Engineer form a sub-group. Planning Engineer spends most of time attending meetings and dealing with problems. Long Term Planning Engineer mainly concerned with critical path networks. Discusses requirements with Operations and Maintenance Engineers and builds on previous outage plans. 'A' Station Planning Engineers schedule work, co-ordinate different groups and determine priorities. Much of time spent dealing with queries and problems in short term. Duties mainly administrative.	Some Engineers enjoy work, most do not. Very little to do with professional or plant engineering. Fairly strong group spirit.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
S.12	'B' Station Planning	Co-ordns. scheduling of work	5D	5 Engrs. 1 1E; 2 x 2E; 2 x 3E	Similar scheduling, co-ordinating and priority allocation to 'A' Station group. Work mostly administrative, about 5% engineering. Very busy with telephone enquiries occupying 1/3rd of time.	Strong group feeling exists. F/M on fringe of group (would probably be included if they were permanent members).
S.13	Work Study Engineers	Supervise timing of jobs	5D	4 x 1E	Form a loose knit group, but each is in charge of a Work Study Unit. Two Units do routine timing of jobs for 'A' and 'B' Stns. Another group recatalogues packs of cards for work blocks (e.g. maintenance of large item). Final group time jobs directly when needed. Engineer typical examines card and decides what needs to be done (priority, etc.).	Work mainly administrative. Engineers will help with general planning during high workload periods.
S.14	Work Study Assistants	Timing of work	7D	13 W.S.A.	Form 4 sub-groups covering routine timing of cards for 'A' and 'B' Stations; recataloguing packs of cards; measuring times on jobs. Bulk of work is timing cards from catalogued times, totalling and entering credits. Any extra work is timed and additional credits given. New jobs timed and entered into catalogue. Occasionally jobs timed directly. Most of work is clerical.	Frequent disagreements over times. Often due to lack of information on cards. Also men do not like system. The 13 form a strong group at work, partly defensive. Share meal breaks, etc.
S.15	'B' Stn. Project Team	To plan, co-ordinate & manage outage maint. work	5D	1 1E; 1 2E; 3 x 3E	The 3 3E's are one from each discipline, but group feeling exists. Programmes are prepared and co-ordinated and job lists and critical path networks created. Contracts are arranged. During outage Engineers monitor progress, deal with difficulties, organise services. Several projects in various stages at any time. Major outage planning lasts about 18 months.	Work is more administrative than general engineering duties. Much of job is acting as communications centre.
S.16	'A' Stn. Project Team	To manage 'A' Stn. outages	5D	1 1E; 1 2E; 3 x 3E	Similar series of stages to the 'B' Project Team. Main function is to collect and co-ordinate maintenance requirements in total and act as a pressure centre to get the planning aspects done and also the work put in hand. Much of work is communicating.	
S.17	Management Audit	Creating & operating management systems	5D	1 SE, 2 x 1E	Setting up [illegible] systems on Station mostly based on computers. (One 1E is a systems specialist). Currently setting up preventative maintenance system. Duties involve discussions with Maintenance Engineers. RHQ computer specialist and setting up programme. The Senior Engineer studies technical and other data and advises Station Manager (and Deputy) on its implications for station. Audit function will be discussing and advising Department and Section Heads of requirements e.g. effects of Health & Safety at Work Act.	To be effective the Management Audit must be persuasive and not coercive.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
S.18	'A' Station Operations Liaison Engineer	To provide link between day staff and shift staff	5D	1E	Much of the work is progress chasing on behalf of shift operations staff. Making decisions of a minor nature to expedite work. Making enquiries for operations superintendent. Getting permits urgently for maintenance. Generally dealing with problems to improve plant availability.	Job is a solo one. Some links with 'B' Station equivalent.
S.19	'B' Stn. Operations Liaison Engineer	Same as for 'A' Station	5D	1E	Similar duties and functions as 'A' Engineer. Some engineering decision-making, but job mostly communicating and administration.	
S.20	Fuel and Ash Engineer	Manage fuel and ash plant	5D	1E	Management aspects include various human relations aspects, etc. Another area is making decisions relating to plant and pressing for work to be carried out when needed. Finally, isolations will have to be checked and signed for in relation to the plant.	

The Cleaners had more closely defined duties which were divided into two types; namely, the "permanent" areas assigned to a man and the "variable" duties which other Cleaners carried out for a few days before transferring to something else. Most Cleaners preferred the permanent duties because they could identify with those areas and take responsibility for their overall state. Many thought that the work pressures were too low in their Branch and that the duties carried out were even less suitable for timing under the Productivity Scheme than the Labouring duties. For example, cleaning a room could mean anything from sweeping the floor to washing everything including the walls and ceiling. N.B. The author observed such varied interpretations being carried out over a period of time by "active" and "inactive" members of staff.

The Transport Drivers comprised a small group carrying out one or two routine duties (e.g. regular tanker runs) and operated a variety of mobile equipment units on the site. Many of the services required of them were very short term, such as moving a crate with a fork lift truck. The Productivity Scheme was manipulated by the provision of excessively long times for a few duties and this enabled the Drivers to provide such services in their "spare" time. Thus, in this case, the inadequacies of the Productivity Scheme were tacitly recognised. The Transport Drivers carried out vehicle maintenance on a surprisingly large number of vehicles on the site (about 75).

The Security Guards carried out a number of subsidiary duties in addition to site security and the proliferation of security systems on the site in recent years made the presence of three necessary, at least during certain parts of each shift.

The Building Maintenance Branch used to comprise a group of about five individuals who carried out minor maintenance tasks and repainted parts of the site. The bigger jobs used to go out to contract. This group is now being substantially increased and will in future carry out all maintenance on site with the exception of very large jobs for which contractors would still be used. The opinion was expressed that the new larger crews would be proportionately far less effective that the original small crew. It was also considered that the large crew had been created partly to absorb staff from the defunct Direct Labour Unit which had been stationed at a nearby town. The new group would therefore be equivalent to a Direct Labour Unit on the site and this ought to be more effective than the previous off site Units who were generally far more expensive than Building Contractors.

The Site Services Foremen are a diffuse group who covered most of the previously discussed groups and the comments about their duties were much the same as those relating to the other Foremen. Namely, that more than half their time was spent on administrative work operating systems.

The Management style of the station was one which included little involvement with other levels of staff and this will be discussed further in Chapter 7 . It was estimated that over a third of the time was spent on industrial relations by the Departmental Heads (and probably more for the senior Management). It might be concluded that senior staff have to spend this amount of time in one form or another on human/ industrial relations. A great deal of time was spent for all these members of staff at committees and meetings and, according to other staff members attending, much of this effort was wasted since decisions were pre-arranged or deferred. Most of the day to day work of running the Departments was delegated by their Heads who spent much of their time co-ordinating activities between Departments. Dealing with station policy matters was generally confined to the senior Management.

The 18 Engineers in the Planning Department were supplemented by other groups in both Maintenance and Operations, giving a total of 33 Engineers who were wholly engaged in various aspects of planning on the site. (N.B. This did not include those so engaged in the Development Department, or the Commissioning Team). Their duties could be broadly divided into long term and short term planning and the "technical" aspects of the Productivity Scheme. Long term planning was carried out by a small group in the Planning Branch supplemented by Maintenance Project Teams for the old and new stations. The long term planning group carried out technical planning functions, such as critical path analyses, which are normally considered as a Management system. Other Management systems, including computer programmes, were prepared by the Management Audit Team and most of these were directed towards the planning function. The two Project Teams were mainly concerned to co-ordinate the plant needs and to feed them into the long term planning programme. Subsequently they monitored the programme during its execution. Nearly all the Planning Branch Engineers were engaged in short term planning and spent up to a quarter of their time at meetings etc., at which plant needs were co-ordinated and finally emerged as a series of daily work programmes which detailed every task to be carried out on the station. Because of the rigid nature of these programmes and the ever changing plant needs, over a third of the time of these Engineers was spent dealing with modifications and additions to the programme (usually over the telephone) and the subsequent re-formulation of the following day's work programme. The Operations Liaison Engineers for each station spent much of their time dealing with the short term facilitation of work. Another group were the Work Study Engineers who managed a team which timed all the jobs (to facilitate the planning) and subsequently checked the actual times on the completion of jobs for the payment of the productivity bonuses.

There was much discussion during this study about the merits of the planning systems and these have been discussed in Chapter 7. It is sufficient to note that the planning function before the Productivity Scheme was mainly confined to the long term aspects and opinions were expressed to the effect that short term planning and work co-ordination were best carried out by the Maintenance Engineers and their Foremen in conjunction with Operations needs. Of necessity, this system operates on shift at present and is likely to continue unless Planning Engineers are assigned to each shift.

The remaining functions which have not been covered are the Fuel and Ash Engineer whose primary role was to manage those services. He also carried out some Engineering duties associated with isolations and the production of permits for work. Another solo duty was that of the Safety and Training Engineer who was almost totally absorbed in the administrative aspects of those two subjects.

Improvement Tasks

A schedule of these tasks is given in Tabl A.19 and they related exclusively to the Development Department and the Commissioning Team. The Mechanical, Electrical and Instrument Sections of the Development Department each had five Engineers and all tackled projects in their own field. Most of the duties concerned longer term improvements of the plant which were generally necessary because of inherent weaknesses in the original design. The post commissioning problem solving period with modern power stations appears to increase exponentially with the size of the units (at least in the U.K.) and the Engineers talked of the old 30 M.W. stations settling down to steady operation after about six months. Most projects carried out went through a typical sequence of stages which apparently involved Engineers for more than two-thirds of their time on procurement work and its problems, including specifications and drawings, contacting suppliers (inquiries, queries and chasing) and subsequently supervising contractors. Their work could have been said to involve finding an engineering solution to a problem and subsequently spending nearly all their time on managing its implementation.

TABLE A.19 - ASH HAVEN IMPROVEMENT TASKS

R.G.S. Johnston 3.8.1978.

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
I.1	Development Mechanical Section	Solve larger mechanical plant problems.	5D	5 Engrs. 1 SE; 2 x 2E; 2 x 3E.	The senior engineer runs the team, allocating projects, advising and providing assistance when required. In addition, he deputises for the Departmental Head. The engineers work jointly on some projects, but most have several individual projects. After the initial investigation stage much of the work is administrative or supervisory (usually of contractors). Projects usually in the £K10 to £K100 range. Writing specifications, supervising preparation of drawings, contacting suppliers and facilitating work of contractors make up much of the workload.	Much of the work not technically demanding. Paperwork increases. More could be done by clerks. Group coherant, members have social links at work. Also feel a part of total Department, but this not so strong.
I.2	Development Electrical Section	Electrical projects & electrical aspect of other projects.	5D	5 Engrs. 1 SE; 2 x 2E; 2 x 3E.	Very similar pattern of work to the mechanical group. One difference is that electrical projects may be sub-projects of (e.g. a mechanical project). Same basic spread of duties, i.e. great deal of admin. type work.	Members have sense of belonging to Section.
I.3	Development Instrument & Control	Instrumentation projects and problems.	5D	5 Engrs. 1 1E; 2 x 2E; 1 3E.	Similar project type work with various stages after problem investigated and solution evolved. (These stages about 12% of time). Chasing supplies etc., takes about 1/3rd time. Contacting suppliers, discussing equipment also about 1/3rd. Commissioning plant, solving problems takes rest.	Work can be fairly demanding of time. Team form a social group.
I.4	Development Technical Services	Dealing with long term plant problems.	5D	1 1E; 2 x 2E.	Similar to others, but emphasis on investigating problems. When this done projects may go to other Sections. Therefore more plant work in this Section.	Three form a social group. Too much time spent progressing jobs in Station. If they are not pushed they will not get done.
I.5	Development Construction Section	Modifications to No. 9 Unit.	5D + 4S	10 Engrs. 1 SE; 2 x 1E; 3 x 2E; 4 x 3E.	Comprises 2 sub-groups. The 4 3E's are on shift and provide a continuous monitoring service of the contract work and provide any facilities (e.g. permits) that they might require. Thus, the work is mainly administration and communication, plus technical checking. Day team work closely with contractors engineers and are concerned to maintain progress and standards by monitoring work and providing facilities. Work has high admin. content.	

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
I.6	Development Drawing Office	Preparation of drawings; technical service.	5D	2 Draughtsmen	Two Draughtsmen (1 Electrical, 1 Mechanical) manage Drawing Office. Also they manage 10 contract Draughtsmen who provide the main detail drawing service. Identifying plant items, interpreting drawings, preparing sketch drawings and setting down engineers' requirements take about 2/3rds of time.	Form strong social unit. Work generally satisfying. The contract Draughtsmen are part of social group at work.
I.7	No. 9 Unit Electrical & Instrument Section.	Rebuilding electrical & instrument equipment.	5D	1 1E; 4 x 2E; 1 x 3E.	Two sub-sections exist, 2 2E's deal with instruments and the others with electrical equipment. Each engineer has plant areas of responsibility. The 1E allocates areas, organises work and helps out when pressure is high. Much of work is dealing with admin. aspects (contracts procedures). Other major items are monitoring progress and standards and recommissioning finished items.	Strong sense of group identity with whole of team. Social links extend outside work. Some feeling of separateness from rest of Station.
I.8	No. 9 Unit Planning & Co-ordinating.	Monitoring overall programme.	5D	1 E.	Runs the planning aspects. General monitoring of work progress. Mainly admin. type duties.	
I.9	No. 9 Unit Boiler Systems.	Refurbish boiler equipment.	5D	4 Engrs. 1 1E; 2 x 2E; 1 x 3E.	Similar duties to the electrical and instrument sections, but relating to the boiler equipment. An additional duty of the 1E (S.H.) is to deal with human relations aspects for all the N.J.I.C. on the No. 9 team. This duty takes about half his time. Most of rest of duties are monitoring work, testing, communicating, etc.	Said N.J.I.C. have sense of belonging much stronger than rest of Station.
I.10	No. 9 Unit Turbine Rebuild.	Monitoring new turbine installation.	5D	4 Engrs. 1 1E; 2 x 2E; 1 x 3E.	Similar duties to boiler group except all work done by contractors. Therefore duties are technical monitoring, liaison and facilitating work wherever necessary.	

GROUP	TITLE OR DUTY	ROLE	PATTERN	COMPOSITION	OUTLINE OF DUTIES	GENERAL COMMENTS BY MEMBERS
I.11	No. 9 Unit Turbine Auxiliaries	Refurbishing turbine auxiliaries.	5D	1 2E; 1 3E.	Organising the supply of items and their installation. Usual steps of tendering, chasing, monitoring and checking. Also organising the dismantling and rebuilding of certain items by Station staff.	
I.12	No. 9 Unit N.J.I.C. Staff	Rebuilding and testing equipment.	7D	4 F/M. 22 N.J.I.C.	The operations team form a sub-group (1 F/M; 1UO; 1 AUO and 2 APA's.) They carry out commissioning checks on equipment. The remaining 3 F/M (1 mechanical; 1 electrical; 1 instrument) and 18 fitters (6 each) work as a close knit team dismantling,rebuilding and installing equipment.	Work satisfying because high standards are set and sufficient time is allowed for these to be achieved. Men feel very much a part of group and separate from rest of N.J.I.C. staff.

The Technical Services Section was similar, but more time was spent on initial investigation of problems which were then broken down into sub-problems and allocated to other Sections. The Construction Section was mainly concerned with the boiler modifications and some of its members were on shift. Nearly all their work was expediting and monitoring Contractors' work on the units and their role was that of Engineering Clerk of the Works. The two Development Draughtsmen managed a team of Contract Draughtsmen who did most of the detail work. This allowed the two Draughtsmen to interpret the Engineers' needs,to prepare sketch drawings and to provide other Drawing Office services.

The Commissioning Team were engaged in the re-building and re-commissioning of a complete 500 M.W. unit and were split into similar Sections to those of the Development Department. Their duties were substantially the same, namely, the technical administration with a greater emphasis on the monitoring of work by Contractors. They mostly differed from the Development Sectionsin having responsibility for the management of industrial staff. Instead of technical problems the Engineers had plant areas for which they were responsible. Overall, the Engineers spent rather more of their time on engineering problems than their Development equivalents as some of the plant work monitoring was carried out by the Foremen. Another duty was the management of men, but this had been delegated to one Engineer and occupied half his time. The last group in this team was the industrial staff and their Foremen and these were divided into sub-groups. Their work mostly comprised of dismantling and re-building equipment, or the re-installation of equipment and associated services. Much more discretion was allowed to these members than was the case in the Maintenance Branches and as a result they considered their time was used more effectively. It was evident that none of the work of the Commissioning Team had anything to do with running the power station and most of the work of the Development Department was concerned with rectifying basic faults in the equipment and was not related to problems associated with normal station operation.

Summary

In summarising many of the comments made it would be true to say that most of the criticisms of the organizational structure were directed at the regulatory services. Some questioned their efficiency and many questioned their need. Some of the comments about the core and maintenance services referred to the indirect effects of the regulatory services, e.g. the Productivity Scheme and the often expressed opinion was that the organization would have been more efficient with greater emphasis on those functions which have been classed as core and maintenance. Improvement services were seldom criticised and were generally regarded as a supplement to the basic organizational structure. Many spoke approvingly of the Commissioning Team and this approval seemed to relate to its separateness, its unified sense of purpose and its ability to minimise the effects of secondary services. A surprising number of the staff resented the misuse of their labour and wanted to do work more directly related to the needs of the plant. This was evident in the greater satisfaction that most shift work gave, despite the unsocial working hours. Many also expressed a desire to work more effectively with a greater work output. However, such matters as job satisfaction are discussed elsewhere in this Report.

The Working Patterns in Overseas Power Stations

The author's visits to three United States Power Stations yielded some information on the work patterns, but the studies were not carried out to anything like the depth of those in the C.E.G.B. Power Stations. Information was also obtained about one or two other overseas power stations, but this was usually in the form of staff structures.

A 900 M.W. Single Unit Coal Fired Station

The organizational structure at this location comprised a Station Superintendent and his Deputy. Reporting to these were the Supervisors of the three main Sections, namely, Results, Operations and Maintenance. Also reporting was an

Administration Supervisor with a total of seven staff within his Section. These were an Administrative Officer; two Pay-Roll Clerks; one Fuel Records Clerk; three General Clerks and Typists. A Safety Engineer also reported to the Station Superintendent and his Deputy and he was qualified in industrial safety. In addition to these Station staff there were on site two groups outstationed from T.V.A. Headquarters. These comprised three Gatekeepers who provided two shift cover on a seven day week and also received visitors and showed film slides to visiting groups. At night the locked gates are monitored from the Control Room by television. The other Headquarters group seconded to the site comprised the Stores Supervisor and Assistant, plus two Clerks and three Warehousemen. The service provided was for six days a week on a two shift system. The total staff on the Station (including the seconded Headquarters staff) comprised 187. Additionally, a small group of Apprentices were on the site for training.

The results section structure is shown in Figure A.20. The Supervisor provided some general information saying that men normally work overtime whenever an outage occurs and there is no limit to the amount. Also, men are switched from other Power Stations if they wish to go and are provided with the basic living allowance therefore the real benefit to the staff would be the opportunity to work long overtime during the transfer period. The Power Stations are basically staffed for steady state operation plus routine preventative and breakdown maintenance. During annual outages the workforce is supplemented and additional labour is hired for major breakdowns. Little or no contract work is carried out excepting specialised services.

If instruments fail the operators normally contacted the Foreman who knew the plant needs and decided the priorities for maintenance work. Men tend to specialise in certain instruments and generally took a pride in sorting out problems.

Figure A .20 - Bull Run Power Plant Results Section

- Power Plant Results Supervisor
  - Assistant Results Supervisor
    - Instruments Unit
      - Engineering Associate
        - Instrument Foreman
          - Senior Instruments Mechanics 4
          - Instruments Mechanics 2
    - Mechanical Unit (Test & Efficiency)
      - Engineering Associate
        - Eng.Aide Statistics and Test
        - Eng.Aide Test and Studies
    - Chemical Unit
      - Engineering Associate
        - Chem.Lab Analyst
          - 3 Asst. Analysts (7 day x 2 shift)
        - Mats.Tester Coal
          - 3 Asst.Mats Testers (Coal Samplers) (7 day x 2 shift)

The Foreman said he expected to help men who were new to certain items of plant, but for the more vital items he would put on the most reliable men. Work order cards were only used as a last resort because all breakdown maintenance was normally done during the same day.

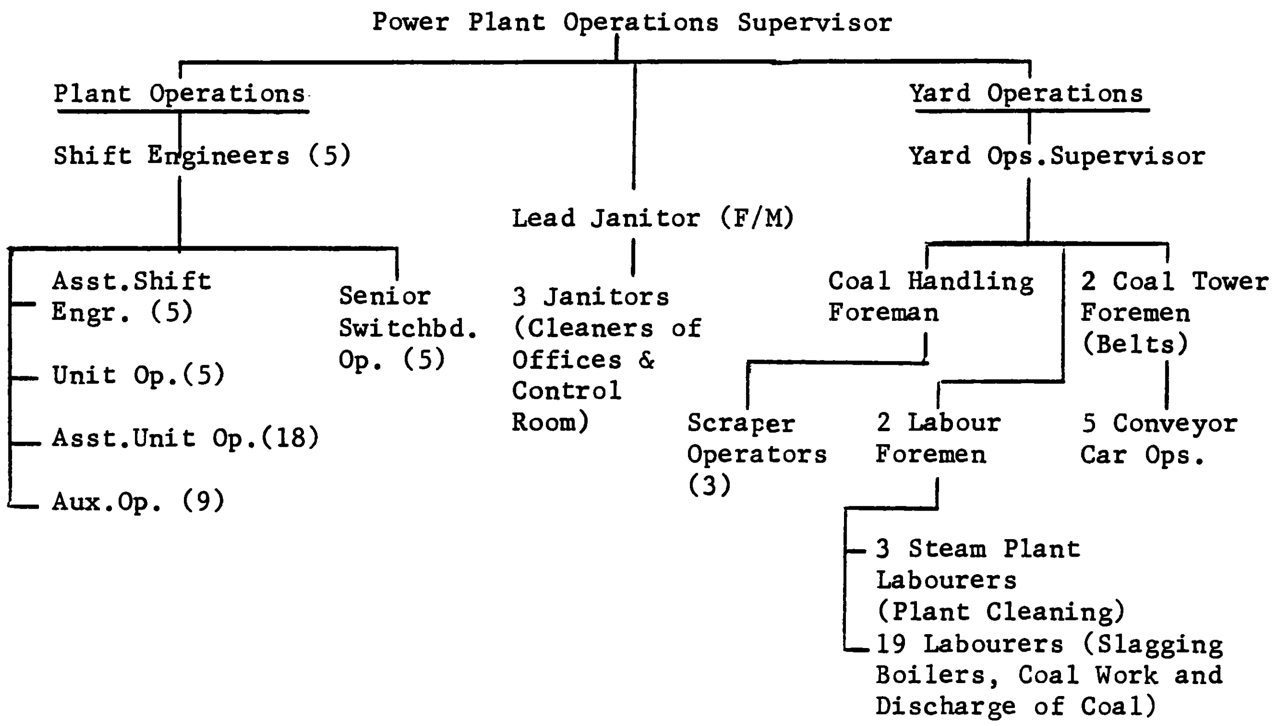
The preventative maintenance programme is devised by the Instruments Engineer who provides the Foreman with a weekly programme. Any technical problems arising would be dealt with by the Supervisor or his assistant who both have University degrees.

The Test & Efficiency Section carry out a series of tests on different time cycles ranging from annual to daily. The Chief Test & Efficiency Engineer analyses the operating data and assesses performance on a long term comparative basis. He also prepares operating statistics which the Results Supervisor uses to prepare statements giving reasons for plant deviations in a report to Headquarters. Much of the chemical analysis is carried out on a continuous basis with automatic equipment. For example, water samples from various parts of the plant were drip fed continuously into the Laboratory and automatically analysed.

It was explained that with the computer controlled equipment and electronic instrumentation the title of Instrument Mechanic was probably not the most descriptive name and Controls Technician would be a better title. They are expected to know how the systems work and how to track down faults. The continuing programme of calibrations and checks is maintained and applies to individual instruments and control loops. The emphasis of the Section is on giving a prompt response to an operating problem affecting their instrumentation which is why verbal reporting is preferred to work order cards. The efficiency of the Section is measured by the effectiveness and reliability of the plant, rather than the amount of work carried out within the Section. As a result, the Instrument Maintenance Section would consider their effectiveness was measured just as accurately by the Test & Efficiency Report as was that of the Operations Department.

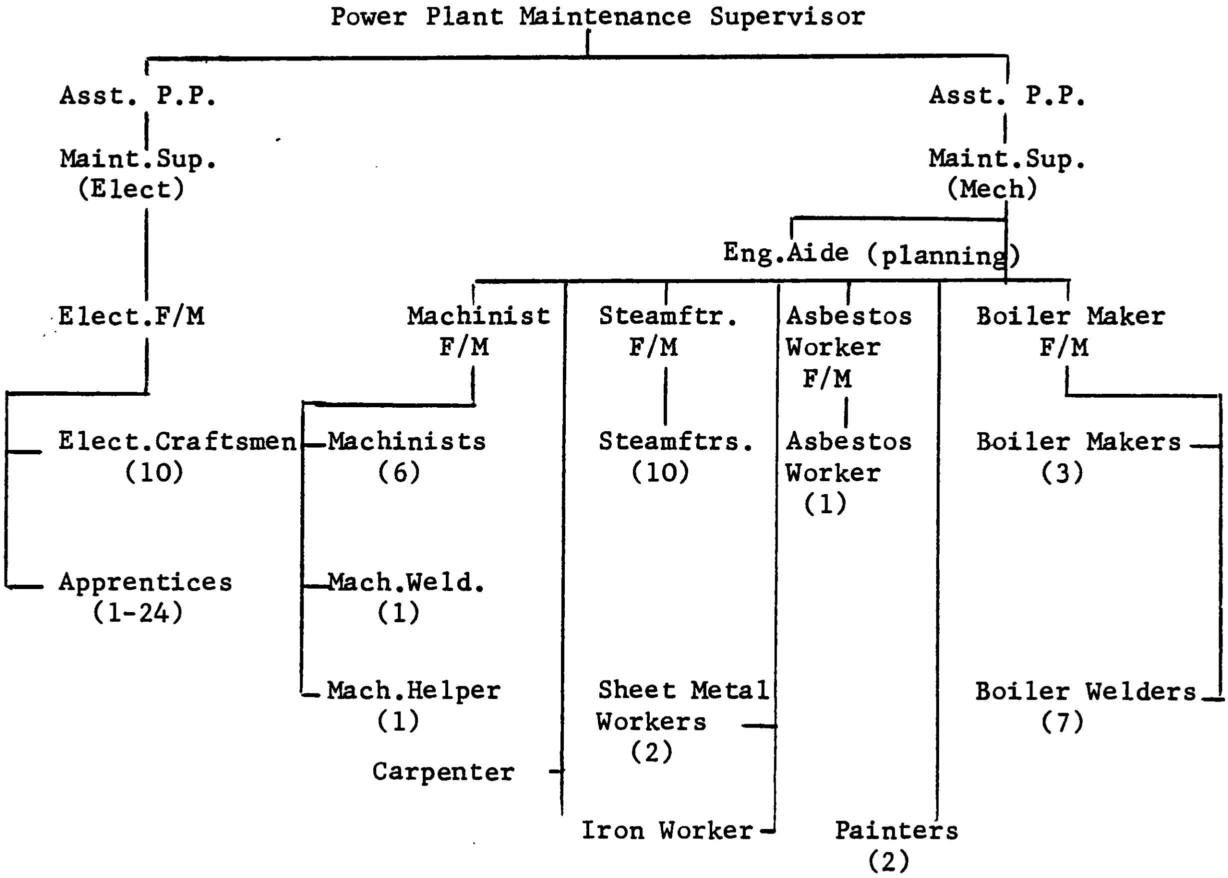
The next Department to be analysed in the study was the Operations and this is shown in Figure A.2.1. As can be seen from the staff tree, virtually all the Operations staff are on shift and divided into two main groups. General management of the shift is the responsibility of the Shift Charge Engineers, but the Operations Superintendent is on call 24 hours a day. Evidently this is not necessarily the style repeated in all Power Stations as it was explained that management styles in T.V.A. plants vary considerably, and some are apparently authoritarian with strict definitions of levels of responsibility, etc. At this Power Station responsibility was allowed to pass down the line and the only Standing Instruction for Shift Charge Engineers was to notify the Operations Superintendent if the unit had to be taken off load. The Assistant Shift Charge Engineer is mainly responsible for isolations and permits and the out of service cards are signed by him and hung on the valves, switches, etc. Isolations are carried out by the four Assistant Unit Operators who also clean and lubricate the plant when required. The Switch Board Operator spends his time in the Control Room monitoring the plant outputs. The Yard Operations are split into a Day Gang and a Two Shift Gang, each covering seven days, although the Day Gang minimise weekend work which is classed as overtime. The Labourers control the discharge of the hopper trains and are also involved in the de-slagging of boilers. A Coal Sampler and a Shift Chemist (shown in Figure A.21) are associated with each shift and provide a continuous monitoring of incoming coal and an analysis of coal samples together with the checking of water samples.

<u>Figure A.21 - Bull Run Operations Section</u>



The final Section at this location is that of the Maintenance which is shown in Figure A .22.

Figure A .22 - Bull Run Maintenance Section



The pattern of work was outlined by the Maintenance Superintendent who pointed out that it is divided into Electrical and Mechanical. The Engineering Aide carries out a planning function which includes organizing supplies and keeping maintenance records. Also reports are prepared for all outages. Defect reports on the plant are prepared by the Operations and jobs which have to wait for an outage are so marked and set aside. These are subsequently sub-divided into crafts and linked with other requests from the Results Section. Additionally, Headquarters may send down requests for work to be carried out on the plant. These would emanate from specialist Engineers at Headquarters. The Engineering Aide prepares lists for the work crews, one for each trade.

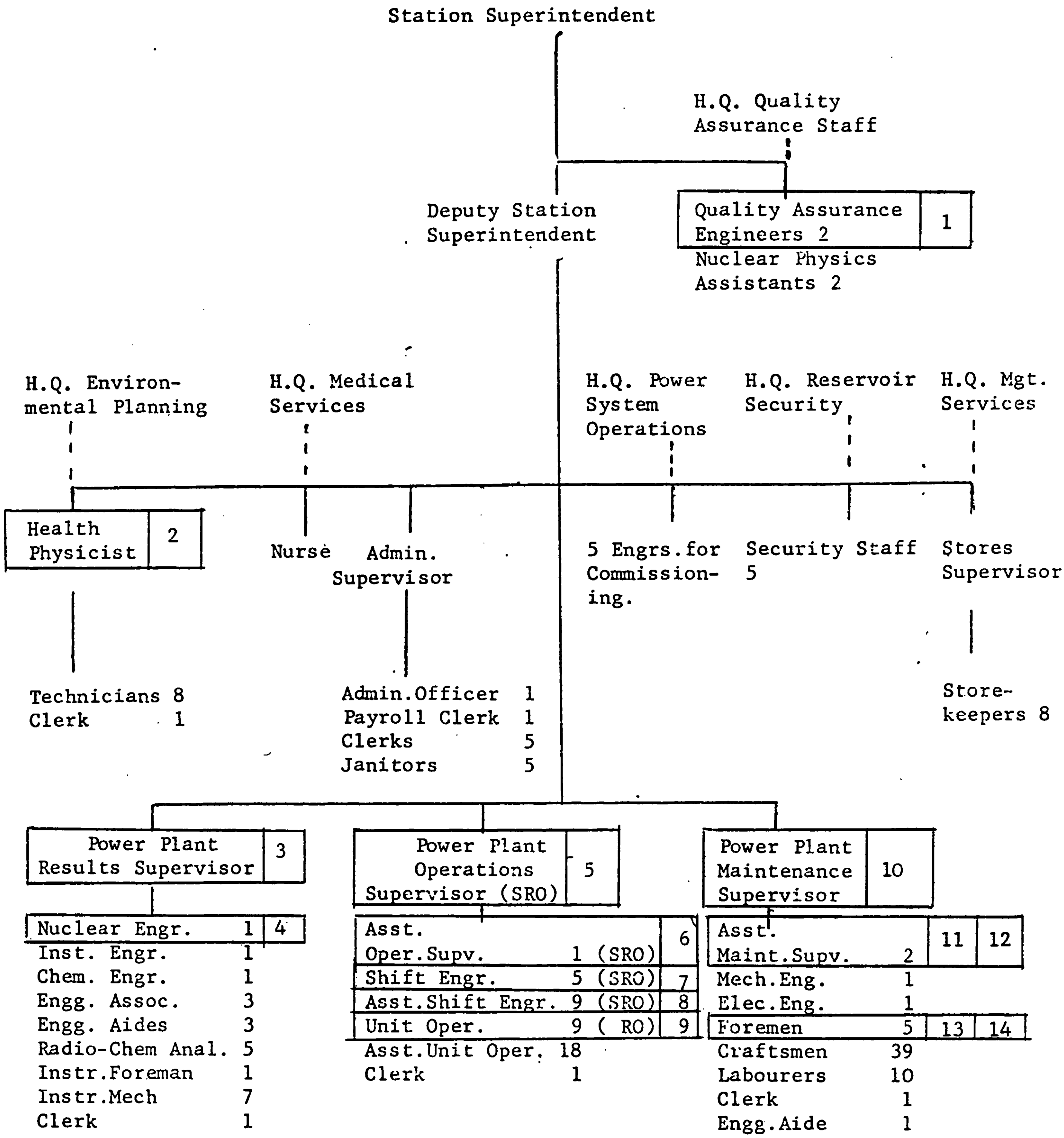
These work lists may be modified, or produced hurredly if an unexpected plant shut down occurs. An example was given of an unplanned outage due to a large slag fall and the unit was expected to be back on load within two days. The planned work load would have lasted for four days and four eight hour shifts were arranged to compress the work into two days. On inspection it was found that the main task would take five to seven days and therefore the long shifts were reduced. Additional Welders were borrowed from another T.V.A. Station and Headquarters took advantage of the longer outage to request additional work on plant modifications. Additional labour was hired for this work which was completed within two days. The example shows the extreme flexibility of the planning system linked to a flexible work force which is motivated by the offer of substantial overtime.

It was explained that casual labour was recruited for such outages through the Local Trade Union Representative who also acted as an employment agent for his Union's members. It was explained that although the Union were insistent that management honour their undertakings to employees recruited, they also co-operated with management in the assessment of mens ability and would do their best to ensure that properly trained and competent members were provided.

Sequoyah and T.V.A. H.Q.

Sequoyah Power Station is a two unit nuclear station, each of which is 1,150 M.W.'s. The station was at the pre-commissioning stage and the construction teams were still on site. However, the organizational structure was relatively complete and the staff tree was as shown in Figure A.23. Some general points should be made, such as the fact the refuelling on pressurised water reactors only takes place during the annual overhaul and, therefore, the health physics risks during the rest of the year are minimal. During this annual overhaul additional health physics staff from Headquarters are on site.

Figure A..23 - Sequoyah Nuclear Power Station and T.V.A.



Total staff (commissioning stage) = 178

Stn = 2 x 1150 MW Units x 2 PW Reactors

SRO = Senior Reactor Operator licence. (issued bu Federal Authority)

No = Job descriptions summarised Table A.24

Environmental testing and film badge processing are also Headquarters functions. During operation, one Technician will be on each shift per reactor and he will monitor the plant and the staff and calculate air sample densities. He will also monitor any items of plant leaving the site and check the laundry before and after treatment.

The basic shift structure for the Station comprised one Shift Engineer with the special Federal qualifications necessary for operation of nuclear power stations. The two Assistant Shift Engineers are allocated one to the Control Room and one to deal with plant isolations. The two Unit Operators are at the Reactor Desks and the four Assistant Unit Operators are generally available on the plant assisting the Engineers.

The Maintenance Superintendent said that all maintenance work is planned as day work and much of it was of a preventative maintenance type. A plant problem identified by Operations staff would be reported on a work order card and would be slotted in to the planned day's work if the urgency required it. In the event of emergency work being required out of day working hours staff would be called out. It was expected that during operation some shift maintenance would be carried out and the crew envisaged would be one Foreman and between four and six Craftsmen and Labourers. They would be under the control of the Shift Supervisor and would otherwise deal with break down work. The Station staff are intended to carry out routine preventative maintenance and break down maintenance, but during annual overhauls a Maintenance Team from the Headquarters would come on to site, probably with up to 300 more staff for the outage period. Normally, the managing of the outage project would be taken over by the Headquarters Team who would be answerable to the Station Superintendent. It was envisaged that when other nuclear stations were commissioned permanent nuclear station Headquarters Maintenance crews would be established.

2300 MW NUCLEAR STATION U.S.A.

TABLE A .24

SUMMARIES OF SAMPLE JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	DUTIES AND REPONSIBILITIES
1	M5	Quality Assurance Engineer	Reports to Station Superintendent. He is reponsible for developing the means of achieving the results and goals desired. Responsible for developing, planning, initiating and directing the nuclear quality assurance and control programme in accordance with the plant operational.procedures. Ensures that all nuclear safety requirements and regulations are obeyed. Keeps the Station Superintendent advised of significant trends in relation to plant operation and safety. Supervises the preparation of standard practice procedures relating to the nuclear plant instructions. reviews all other plant instructions, records, etc., ensuring that quality control requirements are adequately met. Ensures that all station operations and maintenance are performed in accordance with written and approved instructions. Has an overall responsibility for the monitoring inspections of safety related structures and systems and notifies the Station Superintendent of any failures of plant to meet the technical requirements. Is responsible for the training programme associated with quality control. Represents the Station at meetings of Federal Inspectors concerning plant activities and is responsible for the preparation of reports to the Federal Authorities. The post holder must be thoroughly familiar with the equipment and the theory behind the design and operation. He must be knowledgable of all nuclear power station systems and had seven years' experience in plant operation and maintenance.
2	SD3	Health Physicist	The post holder is under the supervision of the Headquarters Health Physicists Department. The main responsibility is the supervision of the Applied Health Physics function at the power station and this requires working closely with the Shift Engineer and Maintenance Engineers. In the initial stages he will assist in the selection and training of Health Physics Technician who provide a Shift coverage. Also familiarisation with the plant and specifications and the operating procedures are an initial part of the work programme. The post holder participates in site and area surveys and employee training. The post holder will prepare work schedules and instructions and supervise the activities of the Health Physics Technicians who provide continuous coverage during normal operation. Routine and Special Surveys of work areas are conducted by the post holder who prescribes work limitations, personnel protective measures in accordance with established standards. The post holder works closely with the Shift Engineers during start-up and shut-down so as to provide all routine and special surveyance necessary for continuous evaluation of radiation conditions. The post holder also works closely with the Maintenance Engineers planning regular or special maintenance and decontamination operations and ensures that Health Physics coverage is available for these functions. The post holder is responsible for ensuring that adequate radiation monitoring and surveyage equipment is available and that schedules for calibration and repair such instruments is organised. Also records of the calibrations, etc. are maintained.
3	M5	Power Plan Results Supervisor	The post holder is under the supervision of the Assistant Station Superintendent. He is expected to use initiative for developing a means of achieving the assigned programmes and work objectives. The post holder provides engineering advice and assistance to the Station Superintendent on related engineering problems. He is responsible for initiating and directing a programme of plant studies and investigations to achieve effective monitoring of equipment and operating conditions and also to ensure compliance with the operating licence. The post holder will also devise systems to enable the efficiency of the heat cycle and equipment to be improved. From time to time the post holder will identify and initiate special tests as required. The post holder co-ordinate activities with the Headquarters Departments and will be responsible for initiating all the measurements and tests associated with the reactors. The fuelling and despatch of spent fuel will be responsibilities for the post holder. Comprehensive instrument maintenance schemes will be initiated and maintained by the post holder. The instrumentation also includes the computers and control systems associated with the reactors. Other areas of responsiblity are the planning and organising of work in the areas of chemisty, radio chemisty and radio-active waste. The post holder has a responsibility for ensuring that the staff under his direction are trained and that adequate levels of discipline and morale are maintained. He is also responsible for ensuring that safe working conditions are established and maintained, the plant safety programme is adhered to by the staff under his direction.

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TABLE A.24

SUMMARIES OF SAMPLE JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	DUTIES AND RESPONSIBILITIES
4	SD4	Reactor Engineer	The post holder reports to the Power Plant Results Supervisor. He has responsibility for ensuring that all calculatations relating to the reactors are carried out and will be personally involved in many of them. Establishes operation and replacement criteria for in core detectors, control rods, core flow orifices and neutron poisons. Also the post holder has a responsibility for ensuring that the Reactor Engineering Assistants are all trained and achieve the necessary levels of competence. He will direct the nuclear surveyance testing and evaluate the results. Any reports and memoranda are prepared by the post holder which relate to the nuclear engineering aspects. The post holder has a responsibility for ensuring compliance with the Federal requirements and operating licence is carried out. The post holder reviews the operating data and recommends necessary action to prevent or correct any conditions affecting safety, reliability and efficiency. The post holder will direct efficiency tests, evaluate the results and prepare reports.
5	M5	Power Plant Operations Supervisor	The post holder is under the immediate supervision of the Assistant Station Superintendent. He is informed of the results and goals desired and has a responsibility for determining the means for achieving those results and goals. The post holder has overall responsibility for the satisfactory and efficient operation of all electrical and mechanical equipment on the plant including the operation of the reactors. He has a responsibility for establishing operations procedures and can make changes based on experience. All such procedures and changes would be determined on their safety and feasibility and also whether they are within the Station licence. The post holder makes overall recommendations for the levels of maintenance to be carried out on the plant based on the information from the shift staff. The post holder is expected to use judgement in determining whether equipment can be safely operated until more convenient times before maintenance can be carried out. He ensures that equipment is made available for maintenance as rapidly as possible. The post holder has overall responsibility for the fuel handling operations on site including the reactor loading. The operation of the waste handling facilities is another responsibility. He is expected to be aware of the assigning of work between different unions so as to avoid disputes. He monitors the work of the shift operating staff by studying logs, charts etc. and takes corrective actions to increase plant safety and efficiency. The post holder organises special studies relating to abnormal operation, outages etc and would consider altering operating conditions.and issues necessary instructions. For major changes he would make recommendations to the Station Superintendent. The selection and rating of operations staff and the maintaining of discipline and morale are the responsibility of the post holder who also has to ensure that the training programmes are carried out. He also has a responsibility for co-ordinating the work of the operations staff with the other aspects of the Station work, possibly through the Assistant Station Superintendent. He directly or indirectly supervises six engineers and 75 trade and labour employees. The post holder must have a minimum of eight years power plant experience and should hold a senior reactor operator's licence.
6	M4	Assistant Power Plant Operations Supervisor	The post holder is supervised by the Power Plant Operations Supervisor. His main function is to assist in achieving the goals of the Operations Supervisor by monitoring the day to day operation of the plant, reviewing the daily reports and giving instructions to the Shift Engineers. The post holder also assists in co-ordinating maintenance work by advising the Shift Engineers of the plant items to be cleared for maintenance. He monitors the details of plant operations and ensures that the equipment is being operated safely and efficiently. He makes recommendations and changes for operating procedures if appropriate and ensures these procedures are updated and understood by the operating staff. Any problems or errors in plant operation are analysed by the post holder who subsequently makes recommendations for any changes. Thepost holder also ensures the quality assurance programme is fulfilled and has line responsibility for the fuel handling operations on site. The post holder also deputises for the Operations Supervisor. The post holder should have had at least six years of power plant experience and should also have been a fully qualified and experienced Shift Engineer. He should preferably hold the senior reactor operator's licence.

2300 MW NUCLEAR STATION U.S.A.

TABLE A.24

SUMMARIES OF SAMPLE JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	DUTIES AND RESPONSIBILITIES
7		Shift Engineer	The post holder is directly supervised by the Assistant Power Plant Operations Supervisor. The post holder is responsible for the start up, operation and shut down of the reactors and turbines and is responsible for the efficient operation of all the associated plant including such equipment as the cooling water systems, waste disposal systems and fire protection etc. The post holder directs the preparation and clearance for maintenance of all electrical and mechanical equipment. He also has overall responsibility for the switching and transmission equipment and for the issue of protective labels for all equipment excepting that covered by the System Despatch Engineer. He is also responsible for the special work permits applicable to all equipment. The post holder co-ordinates the operations, supervises personnel and frequently monitors the plant in order to determine that operating conditions and safety requirements are being maintained. He has to ensure that the load requirements are met and also has to determine the safe, efficient and economical loads that can be carried by the plant having regard for the prevailing conditions of the equipment. He is expected to make requests for load changes when appropriate. The post holder is authorised to contact the maintenance staff when emergency maintenance is required. The post holder has a responsibility to make decision such as removing equipment from service with the minimum of delay in appropriate circumstances. The post holder also has a responsibility for preparing daily reports which cover all aspects of the operations including equipment cleared for maintenance. He also has a responsibility for ensuring the plant is properly manned and for maintaining timesheets for the staff of the shift. The post holder can authorise leave unless it would involve overtime payment in which case approval of the Assistant Operations Supervisor is required. The post holder has a direct responsibility for the safety of all staff working on the plant, being advised by Health Physics in relation to irradiation hazards. The post holder supervises all the staff on shift including any maintenance staff assigned to emergency work. The post holders must have completed eight years of steam plant operation and must hold a senior operator's licence.
8		Assistant Shift Engineer	The post holder is supervised by the Shift Engineer. The post holder is expected to follow established procedures or directions of the Shift Engineer excepting when the situation is critical when personal judgment would be used. The post holder's primary function is to deal with the ongoing situation relating to the plant and provide overall monitoring of all the plant conditions. The post holder will spend a considerable amount of time in the control room checking and directing routine operations. He ensures that the correct parameters are used when changing operating conditions. The post holder has a responsibility for ensuring that the plant is maintained in a clean condition and is responsible for ensuring the equipment is operated both safely and efficiently. From time to time the post holder will relieve other staff members (e.g. Unit Operator) and will direct operations of auxiliary plant from time to time. He has a responsibility for keeping the Shift Engineer informed on the state of the plant. The post holder assists in the training of operators, students etc and ensures that personnel are aware of plant conditions and the safety requirements. The post holder is accountable for the isolation and labelling of equipment and for the re-instatement after maintenance. He will often delegate the work to others but is accountable for it being done. He has to ensure the controls are manned by a Unit Operator at all times or alternatively, carry out the work himself. The post holder should have had at least six years of steam plant operation experience and should hold a senior operator's licence. He should have a sound knowledge of all aspects of power plant equipment including the functioning of reactors. The ability to exercise judgement and act quickly is necessary and also the ability to plan, maintain good industrial relations and exercise effective judgement.

2300 MW NUCLEAR STATION U.S.A.

TABLE A .24

SUMMARIES OF SAMPLE JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	DUTIES AND RESPONSIBILITIES
9	•	Unit Operator	The post holders are under the supervision of the Assistant Shift Engineers and spend the major portion of their time in the Control Room. They can only be relieved by another Unit Operator or by the Assistant Shift Engineer when the plant is operating. The post holders are authorised to deviate from established procedures in emergencies when changing conditions may be necessary to save life or equipment. The post holders are responsible for the starting, loading and unloading of the turbine and reactor and associated equipment The post holder is expected to take records and readings each hour. When the plant is operating automatically the post holder will check the various systems and will operate the plant manually if necessary. The post holder will direct subordinate staff in the making of checks on the various plant items. This includes checking the transitory conditions during run up (e.g. shaft vibrations for example). The post holder has a responsibility to operate the unit safely and economically at all times so as to maintain load schedules. He is also expected to report abnormal conditions to the Assistant Shift Engineer (or the Shift Engineer). An additional duty is to assist in the training of lower grade Operators and students in the technical aspects of plant operation. The post holder generally directs the work of two Assistant Unit Operators. The post holder should have completed four years of steam plant operation experience and must hold an operator's licence. The post holder should have the ability to act quickly with good judgement in emergencies.
10	M5	Power Plant Maintenance Supervisor	The work of the post holder is directed by the Assistant Station Superintendent from whom he receives instructions about goals to be achieved and is responsible for developing the means of achieving those goals. The post holder supervises the work of the maintenance organisation and is responsible for all electrical and mechanical maintenance work carried out on the plant. He has to establish methods and procedures and ensure that an adequately trained staff is available to carry out the work. When appropriate, he has responsibility for devising maintenance methods (and equipment) so as to ensure that maintenance is carried out efficienty and speedily under safe conditions including minimum of radiation exposure. In the event of major breakdowns the post holder is responsible for determining the level of repair work needed and for estimating the resources in men and materials to carry through those repairs in a minimum of time. On such occasions he will have the assistance of the Headquarters staff. Assessments of equipment are expected with recommendations to reduce the frequency of maintenance for the time to carry it out. He has to ensure that the requirements of the quality assurance programme are fulfilled. The post holder has a responsibility for the training, discipline and morale of all the maintenance employees and has a responsibility for approving leave, taking disciplinary action etc. when appropriate. He is also expected to co-ordinate and [illegible] work with the other station requirements. The preventative maintenance schedules have to be developed from records and plant experience and outage time has to be utilised to the maximum in order to maximise the plant availability. The post holder must have a wide knowledge and experience of all types of modern nuclear power station plant including the theoretical training in mechanics, materials etc. He should have had at least seven years' experience in the maintenance of modern plant. The post holder would normally be expected to be a graduate engineer.

2300 MW NUCLEAR STATION, U.S.A.

TABLE A..24

SUMMARIES OF SAMPLE JOB DESCRIPTIONS

STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	DUTIES AND RESPONSIBILITIES
11	M4	Assistant Maintenance Supervisor (Electrical)	The post holder is supervised by the Maintenance Supervisor who has overall responsibility for the whole of maintenance. The post holder is expected to deal with all day to day matters relating to electrical maintenance. He will assist the Maintenance Supervisor in planning and directing of maintenance work particularly that relating to the electrical field. The post holder will supervise the Craft Foreman by assigning work and giving advice on special problems that may be encountered. The post holder assists in the planning and scheduling of maintenance work and co-operates closely with other supervisors in order to ensure work co-ordination. The post holder will inspect work during maintenance in order to monitor progress and to ensure the work is being carried out in a satisfactory manner in accordance with safety and other regulations. The post holder prepares reports on any major equipment failures and makes recommendations to the Maintenance Supervisor for corrective measures. He will be expected to determine the men and materials required to effect maintenance in the minimum of time and also the procedures to be followed. Also studies and recommendations for plant modifications should be made if these will improve efficiency, re liability or ease of maintenance. The post holder will be expected to develop and recommend preventative maintenance programmes so as to ensure the maximum utilisation of outage time. The post holder will also assist the Maintenance Supervisor in the administrative aspects of the work such as the preparation of the work and leave schedules and assist in the selection and rating of employees and the pursuance of a training programme. The post holder will ensure that safe working conditions are maintained at all times and that accurate records of the maintenance of equipment are kept. The post holder should be a graduate electrical engineer with a high level of knowledge of nuclear electrical plant and a minimum of two years' maintenance experience. He must also have the ability to direct the work of others and administrative ability.
12	M4	Assistant Power Plant Maintenance Supervisor (Mechanical)	The post holder is under the supervision of the Maintenance Supervisor and is expected to use initiative in carrying out the day to day responsibilities related to the mechanical maintenance of the complex nuclear plant. He assists in the planning and directing of the mechanical maintenance work co-operates closely with other supervisors in order to co-ordinate that work with other site work. The post holder will inspect the maintenance work in progress and ensure that the desired quantity and quality standards are maintained and also that safety and other regulations are adhered to. The post holder monitors work in progress and deals with work requests. He keeps the Maintenance Supervisor informed of progress and refers up any major problems. Reports relating to plant failures have to be prepared together with recommendations. The numbers of men and material required to carry out repairs in the minimum of time are estimated in the event of major outages. Recommendations for changes in maintenance procedures and plant modifications are made if these will improve efficiency, reliability or speed and ease of maintenance. The post holder assists the Maintenance Supervisor in the administrative aspects such as preparing work and leave schedules, changing work plans to meet the plant requirements and assisting in the selection of employees and their training. At all times the post holder will ensure that safe working conditions are maintained in accordance with the nuclear regulations. The post holder should hold a degree in mechanical engineering or have the equivalent training and experience. A high level of knowledge of modern nuclear power station plant is necessary together with a minimum of two years' maintenance experience. The post holder must be able to direct the work of subordinates and should have administrative ability since inefficient maintenance reduces availability resulting in large monetary losses.

2300 MW NUCLEAR STATION U.S.A.

TABLE A.24

SUMMARIES OF SAMPLE JOB DESCRIPTIONS

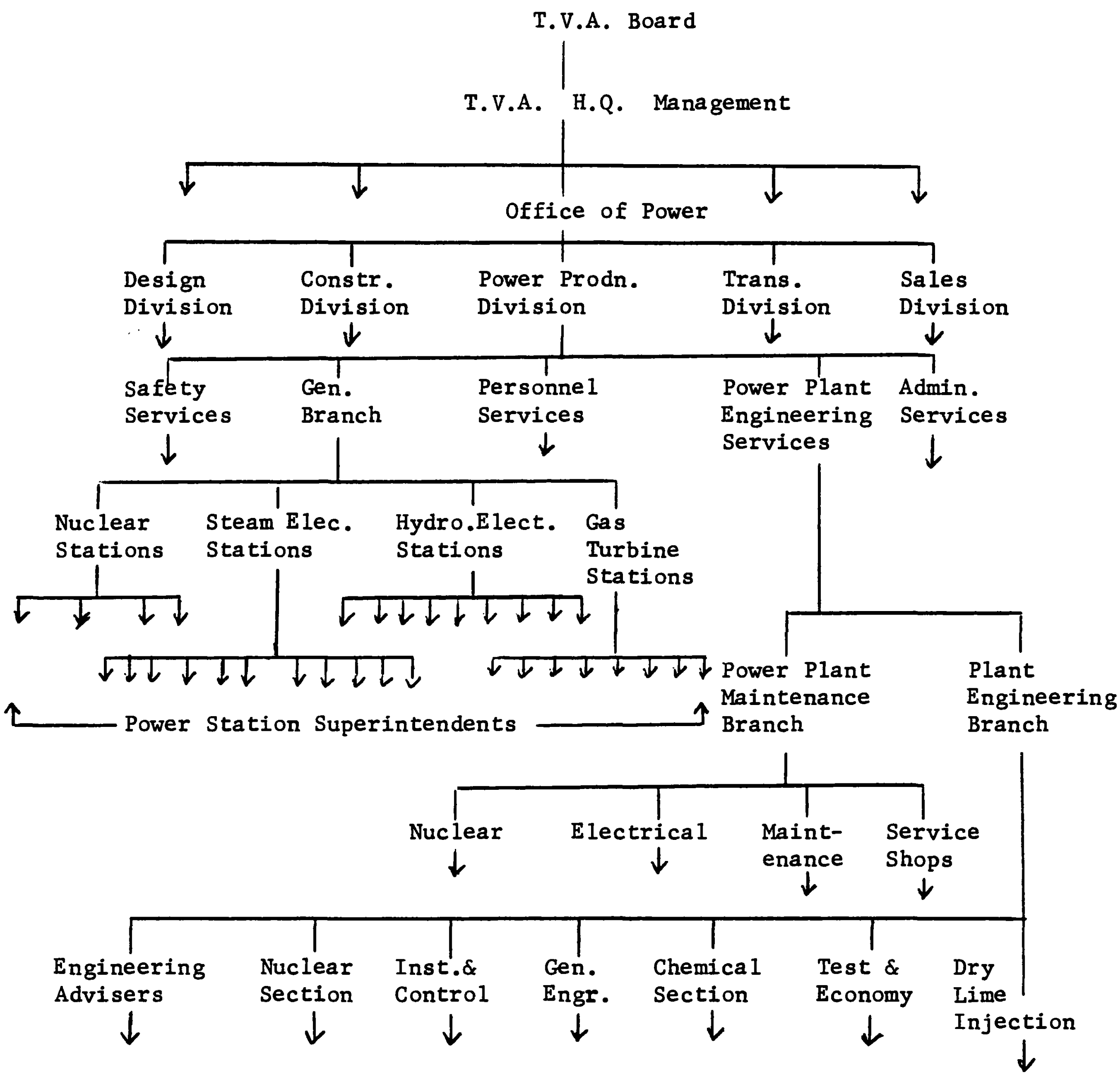
STAFF TREE NO.	GRADE	DESCRIPTIVE TITLE	DUTIES AND RESPONSIBILITIES
13		Boiler Maker Foreman (Nuclear Plant)	The post holder is under the direct supervision of the Assistant Maintenance Supervisor (Mechanical). The post holder supervises the maintenance and repair of the nuclear plant equipment which includes the reactor vessels and containment vessels, auxiliary boilers and feed water heaters, condensers, evaporators and heat exchangers He is also responsible for the operation of the boiler makers' workshop. The post holder submits timesheets for the employees and keeps records of any radiation exposure. He also maintains equipment maintenance information for use in the history and maintenance cost records. All the maintenance activities are carried out in accordance with the quality assurance requirements and reports and records are prepared as required by them. The post holder is directly responsible for the safe working performance of the employees supervised and has to ensure the men are aware of and follow the safety rules and practices. Any unsafe conditions have to be corrected and reported to the Assistant Maintenance Supervisor. The post holder will assist in the preparation and reviewing of maintenance instructions and will make reports on any special constructional problems which later arise. The post holder will supervise the Craftsmen, helpers and apprentices assigned to the plant. Postholders should have a high school education and at least four years' experience as a Craftsman/Boilermaker, also a thorough knowledge of basic mechanical principles and plant maintenance practices and procedures. The post holder should be able to prepare concise reports and able to plan and implement work activities and supervise work in accordance with maintenance schedules.
14		Machinist Foreman (Nuclear Plant)	The post holder works under the direct supervision of the Assistant Maintenance Supervisor (Mechanical). The post holder supervises the maintenance and repair of nuclear plant equipment including the control rod drives, the reactor recirculating pumps, steam turbines and governors and pumps in the radioactive zone. He also supervises the operation of the machine shop. In addition he supervises the maintenance of heavy equipment in the plant site yard and has a responsibility for maintaining the tool inventory and the efficient functioning of the tool room. The post holder will submit reports and keep records of employees' timekeeping and radiation exposure. Equipment maintenance information is prepared daily for use in the equipment history and cost records. All maintenance activities are carried out in accordance with the quality assurance requirements and the written reports and records required by them are maintained. The post holder has a direct responsibility for the safe working performance of all employees under his supervision and has to ensure the men are fully aware of the safety rules and follow them. Unsafe conditions are checked and corrected when possible and also reported to the Assistant Maintenance Supervisor. The post holder assists in the preparation of maintenance instructions and makes reports on any special problems which may affect maintenance. The post holder supervises the Craftsmen Apprentices and labourers etc assigned to the plant. The post holder should have a high school education and at least four years' experience as a Craftsman/Machinist with a thorough basic knowledge of mechanical principles, maintenance practices and procedures. He should have developed skills in identifying faults or potential breakdowns of equipment and demonstrate the ability to lead a crew. The ability to prepare reports and to plan and implement work activities are necessary for this post. The ability to carry out work in accordance with written maintenance instructions is also necessary.

The Results Supervisor was responsible for what would be described as engineering services in a U.K. power station. The anomaly of Instruments being a part of Services rather than Maintenance, would probably be altered in a few years time. The Reactor Physicist carried out reactor calculations and monitored the burn up conditions with three assistants. When the plant was fully commissioned the assistants might be reduced in number. The Test & Efficiency Group carry out normal monitoring studies on the non-nuclear side of the plant. The Chemistry Branch was supplemented for the commissioning period until the plant operating conditions had settled down. Most analyses were of water and difficult ones would be transferred to Headquarters. The Results Supervisor dealt with administrative matters, but hoped to spend half his time on development projects and any design changes. The normal pattern is for the Foremen to allocate work to the men and to ask for any extra help if it was necessary. The men are qualified in certain types of instrumentation before they are allowed to work on the plant. The Station Manager held regular meetings with his senior staff, but also had direct contact with all the other staff at the location. With the small numbers involved this was relatively easy. He worked an extended day in much the same way as U.K. Station Managers do and the common practice in the United States is to have a working lunch using sandwiches. Canteens in power stations are minimal and comprise drinks machines and one or two tables with chairs. A microwave oven is provided for shift staff. At this location a full set of job descriptions had been prepared (by the T.V.A. Headquarters Personnel Department) and a cross-section of 14 were selected by the author as being representative. These are briefly summarised in Table A .24.

The job descriptions prepared by the T.V.A. Headquarters were similar in content to the earlier descriptions prepared by the Regional Personnel Department. These primarily comprise a list of the responsibilities relating to a post, rather than an attempt to describe the actual working patterns of the post holders. However, from the Table it can be seen that most of the tasks are markedly similar to those in a C.E.G.B. power station, with the exception that the vertical and horizontal spread of staff is very much less. This appears to result in a much wider range of duties for the average individual. All the Line Managers double up as professional Engineers and they are also their own planners. The day to day organizing of work is not only carried out by the Foremen, but is their responsibility. It would seem as if the Craftsmen are adequately trained and expected to use their skills in the solution of plant technical problems.

During a visit to the T.V.A. Headquarters some information about the working organization and some statistics were made available. The T.V.A. is a Federally owned authority which covers a wide range of functions in addition to the generation of power. The geographical area covered is roughly equivalent to that of England and Wales together, with a distance of about 400 miles between the most widely separated power stations. The total generating capacity is about half that of the C.E.G.B., but the organization only has one Headquarters group. The organizational structure is shown in Figure A.25. Some information obtained was that within the Office of Power the Design Division designed power stations in their entirety and also design the major modifications for existing power plants. The Construction Division were responsible for constructing the power stations, including the hiring of direct labour. The manufacturers would be used to assemble such specialist items as turbines. Some of the nuclear plant has been designed and substantial parts of the installation carried out by the manufacturers. The organization operates in much the same way as the C.E.G.B. insofar as all equipment is purchased by competitive tender and the T.V.A. is obliged by law to take the lowest tender. They said that this policy has disadvantages and that other Electricity Undertakings would not buy the cheapest item if they felt it to be in anyway unsatisfactory. The Headquarters Generation Branch includes Sections such as that

Figure A.25 - The T.V.A. Organizational Structure



covering plant operation, whose main function is to organize and sequence the whole programme of major outages for the year. The peak load demands of the T.V.A. include a small Winter peak, but the neighbouring utilities have Summer peaks and this results in a fairly steady load throughout the year. Also, the load factor throughout the 24 hours is much better than that in the U.K. due to the extensive use of central heating and air conditioning. The preferred times of maintenance are the six weeks in Spring and six weeks in Autumn. Thus, the high merit units are off during the Spring and Autumn slack times and the lower merit plant is off at other times in the year.

The general pattern of staff build up in new power stations is similar to that adopted by the C.E.G.B. with the Station Manager moving onto site about 18 months before commissioning and the early stages are concerned with recruitment, training and the taking over of plant items. Much of the maintenance work is carried out by crews from Headquarters and particularly so in the case of turbines and other big items of plant. Full unit outages last about 16 weeks, which includes a total overhaul of the whole plant.

The numbers of staff employed in a power station varied, particularly so with the type of station. One older station with ten 150 M.W. units had a total staff of 265 (coal fired). Another ten unit station (1,750 M.W.'s) had a total staff of about 165. A four unit older coal fired station (units 250 and 275 M.W.'s) had a total of 130 staff. The plant at present in use, or under construction at the time of the study, comprised:-

(a) 109 Hydro Units from 2 M.W. to 75 M.W.
(b) 65 Coal Fired Units from 36 M.W. to 1,300 M.W.
(c) 148 Gas Turbines from 25 M.W. to 80 M.W.
(d) 17 Nuclear Units in the range 1,100 M.W. to 1,300 M.W.

An additional eight similar sized nuclear units are actively planned at present.

The industry has generally good industrial relations with a no strike agreement operating. T.V.A. is under a Statutory obligation to pay the average rates for the various crafts in the area. The annual negotiations centre about the two sides interpretations of the average rate in the area.

The staff in power stations are either professional Engineers recruited from college, or Technician Engineers who gained training and experience within the Authority. The professional Engineers generally start as specialists in Headquarters and subsequently transfer to power stations, generally on the maintenance side. The Operations staff usually start at the lower grades and progress in steps of off site training and plant experience through all the grades. At the end of the four year training period the men are considered to have specialised skills equivalent to engineering degrees. The training fall out rate is about 25% and the staff are not allowed a second attempt at the programme (other than one examination re-sit). As a result, Operations Supervisors tend to be company trained men and Maintenance Supervisors tend to be university trained men. Either would be considered to have an equal opportunity for the senior posts, including Station Superintendent.

An interesting insight into the workings of the system was afforded the author during the visit. During the middle evening the ambient temperature was exceedingly high and the T.V.A. plant available was extremely low. Only one or two of the larger units were available and one 1300 M.W. unit was being brought back on to load. The Headquarters computer was able to call up any information on any unit within the system and in their anxiety to get the large unit on load it was tripped at about 80 M.W.'s. After cooling it was again brought on load and rapidly picked up to 1300 M.W.'s. During all this period all the surrounding Power Companies were signalling their available capacity and the cost per unit for the T.V.A. Although this normally gives the T.V.A. control of choice, the demand was such that all available output was being purchased and the danger of shedding load was approaching. Fortunately a violent thunder-storm broke which not only caused a rapid drop in temperature, but also put some of the power lines out of action and enforced power cuts. The following day two other 600 M.W. units were put on load and the following week three further 1100 M.W. units were scheduled to go back on load.

The Maintenance policy of the T.V.A. is to open up turbines once every five years. The technical responsibility for all work on turbines is taken by the Headquarters Engineers. Teams from Headquarters can handle ten turbines simultaneously and similar levels of expertise are available for the boiler work. For boiler work however the industrial staff are provided by the station. A typical Headquarters crew comprises two specialists who work ten hour shifts six days a week. Also two Machinist Foremen, one for each shift and eight Craftsmen (four Machinists, two Riggers and two Steam Fitters). This crew will work on the site on a 20 hour a day basis and will hire typically an additional 12 to 15 hourly paid Machinists at the location. Although all the labour is unionised, a considerable part of the labour force in the States only works part time, the remaining time being spent at home which might typically be a small holding. Such labour would be recruited regularly for the 16 weeks and would come to be regarded as a permanent part time member of the Maintenance crew for a particular station. With high levels of overtime, such a working pattern could easily be equivalent to half a years pay.

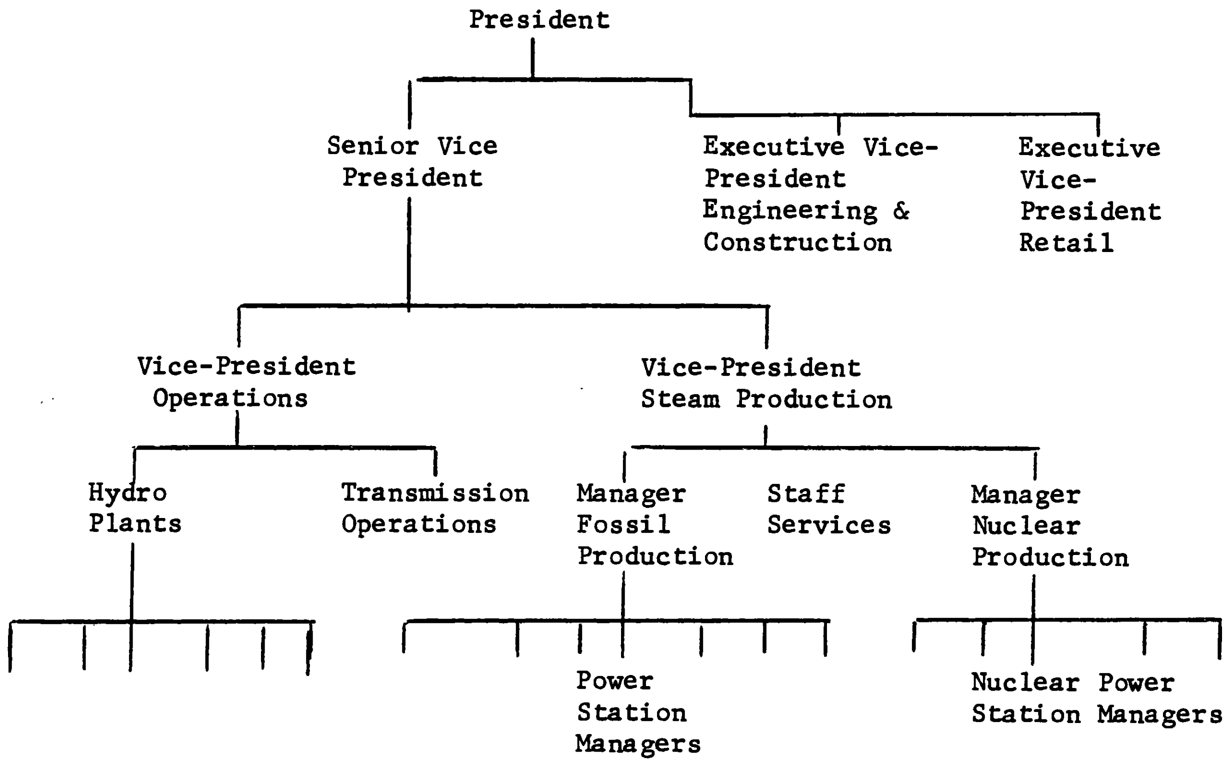
Recently the T.V.A. has negotiated with the Unions to operate a mixed trades agreement, the basis of which is that the various crafts will be recruited in proportion to the total work load and will subsequently work without adhering to rigid demarcation lines. This system of mixed trades is working well apparently in the newer stations and with the younger men, but is not so acceptable on the older stations or with the older men.

The training programme operated for Craftsmen covers a total of 8,000 hours spread over four years. Two hundred hours are spent in the class room per year and the remainder is spread over various aspects of work shop training, plus experience in power station plant. Examinations are held at frequent intervals. Other information was given on pay rates, sickness schemes and retirement and the information will be presented in the appropriate Chapters.

Marshall 2,000 M.W. Four Unit Coal Fired U.S.A. Power Station

This station belongs to the Duke Power Company which is an investor-owned Corporation. It operates nine coal fired plants, 22 hydro plants and 2 nuclear plants are near completion. Six further nuclear plants are planned, or under construction. The transmission network covers 9,000 miles and the total capacity of the coal fired plant is 12,500 M.W.'s. The Company distributes electricity direct to the users and a subsidiary Company buys and sells electrical equipment, ranging from power station plant to cookers and other retail items. An Estates Company purchases land for the creation of lakes and sells leases on the shores of such lakes. The Company also owns coal mines. The organizational structure of the Duke Power Company is shown in Figure A.27. The Engineering and Construction Division designs and constructs the power stations and also carries out major maintenance functions. The Maintenance Branch has a total staff of about 400, including Engineers. The Construction Division employs several thousand staff, ranging from senior Designers to site Labourers. The Steam Production Branch has a total staff of 1,873, which includes Headquarters Laboratory Groups. The Headquarters Department is also responsible for training programmes, the planning of operations and maintenance programmes, Systems Analysis Group and a Technical Services Branch.

Figure A.26 - Organizational Structure of Duke Power Company



A typical major outage organized by Headquarters would last up to eight weeks and involve as many as 200 additional staff. The tasks might include re-tubing the boiler, or a full turbine overhaul. Also, any additional capital works might be included within the programme. The more normal major outages last five to six weeks with an additional 140 staff on average. Detailed work programmes for the outages are worked out by Headquarters in conjunction with the station staff. The outstanding maintenance work is slotted-in to the overall programme.

The organizational structure at the Marshall plant comprised a small Administration Group and Operations, Maintenance and Technical Services Branches. The structure of the Operations Branch is shown in Figure A.27. Most of the staff are grouped into four shifts, each with a Supervisor, an Assistant Supervisor and eleven support staff. The two older units on the plant (350 M.W. each) are jointly controlled by one computer. The computer system is used for logging, sequence monitoring, data logging, performance monitoring and sequence control. Read outs of optimised heat losses for elements of the plant enable the operator to assess the overall state. The Operations Team isolate and make the plant safe after which the items are labelled with the signature of the isolating individual upon them. The station carries out no shift maintenance, but a call out system is operated if any urgent work is required. If there is a short fall of staff in any shift team then some of the day Operations Engineers are available for stand-in and the Team is authorised to operate up to three members short.

Figure A.27 - Marshall Plant Operations Branch

Operations Superintendent

Shift Operations Team	Day Operations	Fuel Handling Team
4 shifts each comprising 1 Shift Supervisor 1 Asst.Shift Supervisor 4 Unit Controllers 4 Asst.Unit Controllers 3 Plant Assistants	3 Young Graduate Engineers 2 Engineers experienced in Operations & Maintenance *	2 shifts x 7 days 4 Supervisors + 24 men **

* Ensure routine checks on the plant, organise planning, deal with Personnel problems, available for night call-in.

** NB. On four days of the week there is single shift operation and on three days there is double shift.

The Maintenance Branch at the station worked a 7 day cover pattern similar to that of the C.E.G.B. The main difference is that only half the staff work Thursday, Friday, Saturday and Sunday, i.e. a two weekends in four system. Certain of the Maintenance Foremen are on night call and evidently the call-outs average one in approximately two to three weeks. Also Storekeepers are liable to be called out at night, especially during outages. The Planning Engineers are primarily concerned with the long term planning, including the preparation of schedules for outages. The Maintenance Branch at the station is shown at Figure A .28.

Figure A.28 - Marshall Plant Maintenance Branch

Maintenance Superintendent

Maintenance Supervisors (Foremen) 4	Stores Supervisor	2 Planning Engineers
38 Craftsmen (Welders, Machinists, Mechanics, Repairmen)	4 Storekeepers	1 Clerk

The Technical Services Branch is shown in Figure A.29 and carries out the three main functions of Chemistry, Instrument Maintenance and Test & Efficiency. The Instrument Mechanics carry out preventative maintenance routines, defects, repairs and circuit and control testing programmes. The Assistant Plant Engineers record the performance data and keep the coal consumption records and take measurements for the purpose of carrying out plant improvements.

Figure A.29 - Marshall Plant Technical Services Branch

Technical Services Superintendent

Station Chemist	Test Supervising Foreman	Assistant Plant Engineer
6 Technicians do all routine analyses mainly water, coal, ash, etc.	10 staff primarily Instrument Craftsmen dealing with instrument maintenance and testing programmes and alarm systems.	2 Junior Engineers

The Station Superintendent estimated that the coal, ash and soot blowing plant occupied nearly all the maintenance efforts. The plant had been the most efficient coal fired station in the United States for nine consecutive years, but the construction of the Bull Run plant (T.V.A.) and the Bellews Creek plant (Duke Power) caused it to be rated third. In addition to an efficiency value of 38.1% (1975) its availability was 86.2%. Departmental Heads at the station were young Engineers who had recently been brought in from Headquarters. The three previous Heads had all been promoted to the new station at Bellews Creek. The Station Manager said that the usual pressure existed between the Operations and Maintenance due to the Operation's desire to get the plant back on stream and the Maintenance's desire to carry out a more thorough job taking a longer time. However, the level of co-operation between the two Departments was extremely high. During this visit the opportunity was taken to meet one of the Headquarters Engineers who was to take responsibility for the major overhaul which was about to commence. The visit was to co-ordinate the plans and programmes of the Headquarters and station teams and it was evident that a close co-operation existed between the two groups. I was assured that because the station had so few Engineers the specialist Engineers from the Headquarters are accepted and welcomed on the station and they knew they had a relevant role to play in the efficient functioning of the station. In addition to its pre-eminent position in the merit order and despite its total staff of 180 the station managed to have a sign outside its gate saying it had suffered no lost time accidents for the last five years. The author was also very impressed by the cleanliness of the plant.

Some Notes on the Detroit Edison Power Company

These notes are derived from a report written by one of the Region's Station Managers following a study visit to this Company in 1962 . The Company serve a population of 4½ million and had an installed capacity (in 1962) of 4,100 M.W. It is an investor-owned Company, but it is interesting to note it had 100000 stockholders and over 1/3rd of the employees in the Company held capital stock. The Company was particularly proud of their very low accident record, which was the main reason for choosing it for the visit.

The organisation possessed a fairly substantial HQ structure with departments for the usual functions such as Personnel, Legal, Accounts etc. One major department dealt with Sales and another with power station construction; this latter group also covered centralized maintenance. At each of the 7 Power Stations (except the nuclear) there were 3 Branch Heads. Five of the seven had deputy station superintendents and five had assistants to some or all of the 3 Branch Heads. All had four shift supervisors. A more detailed study was carried out at one of the power stations (River Rouge) which had three units (2 + 260 MW plus 1 x 321 MW). The basic organizational structure was the same as at the other power station namely, a Technical, an Operations and a Maintenance Branch. The Operating shift teams each comprised 17 staff, one of whom was the Shift Charge Engineer and another the Assistant. None possessed degrees, but had progressed from lower grades through training programmes and promotions. The 15 remaining staff were divided into five teams each comprising a Supervising Operator, a Power Plant Operator and an Assistant Power Plant Operator. Three of the teams had responsibilities for one of the three units and a fourth team dealt with all the auxiliary equipment. The fifth team was available for unscheduled work which included relief work, emergencies and special assignments. The teams carried out all the various tasks on a rota system.

The report noted that the total staff at the station was 176, a figure which included the Gatekeepers, a Nurse and four Canteen staff. The station has undertaken a work simplification programme which encourages all employees to seek ways of improving the efficiency of the organization. Awards are paid of 25% of the first year net savings up to a total of 2,000 dollars (1962).

The Company adopted an enlightened approach to human relations and was greatly influenced at the time by the work of Likert who acted as advisor to the Company (same State). Group structures and working were encouraged and practiced.

The Company operates a centralised power plant maintenance system which is incorporated into the Construction Division. The Division includes a centralised Work Shop capable of dealing with most plant repairs in the Company's power stations. Contractors are normally never used for any Company work. Major overhauls are carried out by the centralised work shops and all the industrial staff are Fitters, no Mates or Labourers being employed. All the Fitters were graded and paid accordingly and the top grade of Fitter was rated as First-Class in his primary craft and held a Second-Class Certificate in an additional craft. The other grades of Fitters are either First-Class in one craft, or Second-Class in one craft. With training it was expected that all Fitters would achieve the Top Grade. It was noted that before these changes (1953) one plant had 120 men engaged on maintenance plus 8 Foremen and now operates with 19 men and 2 Foremen. In general, the new system has resulted in a reduction in staff levels of 40%. The report also deals with human relations and safety and these aspects are covered in other Chapters.

St. Laurent and Martigue Power Stations, E. de F.

Information about these two stations was obtained from a report following a visit by a member of staff of a Regional power station in 1975 . The St.Laurent power station comprised two gas cooled Magnox reactors, each of which drove two turbo-alternators and the total output of the station was approximately 1,000 M.W.'s. The Martigue plant comprised four 250 M.W. oil fired units. The author noted several differences in the staff behaviour patterns from the U.K. patterns. All the staff worked the same number of hours and a formal handshaking greeting was the custom between all members of the organization. Tea breaks did not exist and drinks were taken at vending machines at convenient times in an individual's work cycle. There were no clear distinctions between the different groups of staff (e.g. N.J.M.; N.J.B.; N.J.C.; N.J.I.C.) and the observer expressed the opinion that this was a major contributory cause to the absence of an "us" and "them" attitude at the stations. He also noted that the classification "Engineer" only applied to those holding the equivalent qualification of C. Eng. The writer also pointed out that although the stations were run almost exclusively without Engineers, the qualifications of the staff were very similar to those in U.K. power stations.

The Operations staff were divided into six shifts, which resulted in a number of spare shifts being available. These spare shifts were used for relief work, for training (of a very high standard) and for periods assisting the Maintenance Department with their work. At one of the stations the bulk of the plant monitoring services, such as analyses, plant measurement and statistics gathering, were carried out by the members of each shift in turn during a period on days. There were two or three permanent Technical Controllers in charge of these services. Each of the shift teams comprised a Shift Charge Technician and an Assistant, 2 Foremen, four Unit Operators and three Plant Operators.

At this station (Martigue) the Maintenance Department was divided into a Preparation Section comprising seven persons dealing with methods study, planning, plant history and technical drawings; and an Execution Section comprising 85 members of staff divided into mechanical maintenance; boiler maintenance; electrical maintenance; and instrument maintenance.

The Administration Department was similar to those found in American Power Stations and comprised an Administrative Officer and Assistant plus a Secretary and three Typists. The Stores function came under the Maintenance Department. All the staff were paid monthly from Regional Headquarters. There were also a Station Nurse and a Safety Officer on the site. It should be noted that at this station there were only six professional Engineers out of a total establishment of 199.

At the Nuclear Station the total establishment comprised 407, of whom 10 were in an Administration Section and 11 in a Safety and Security Section. The Operations Branch provided separate shift teams for each of the reactors and a third shift team for the auxiliary oil fired power station. All the Shift Charge Technicians have responsibility for the efficient operation of their plant and also for handing plant over to Maintenance in a safe condition. The three Unit Operators on each shift regularly change the three duties, one being responsible for shift health physics monitoring, one operating the reactor from the Control Room and the other in the Control Room having responsibility for the conventional side. Fuel handling is operated on a two shift basis and includes responsibility for the fuel store, fuel preparation and also the handling and despatch of spent fuel.

The Maintenance function is broadly divided into a Mechanical Section, an Electrical plus Instrument Section, and the Fuelling Machine. Each Section has work preparers (equivalent to Assistant Engineers), Foremen, Technicians and Craftsmen. Maintenance are also responsible for the operation and maintenance of the fuel machine. The Operations side comprises two men per shift for each of the two machines and they generally work in close co-operation with the Operations staff and consider themselves a part of the Operations team. Within the Maintenance Department is a Planning Section, which also has responsibility for the Stores, the Drawing Office and the station cleaning facility.

The Technical Services Department is sub-divided into six Sections. These are briefly listed as follows:-

Reactor Physics comprises three Engineers with responsibility for the reactor state, the fuelling programme and monitoring reactor conditions.

Non-nuclear Testing carries out measurements and tests on the non-nuclear plant, e.g. vibration monitoring.

The Health Physics Section carries out the normal function of monitoring effluents, keeping film badge records and ensureing observance of the safety standards.

The Chemistry Section carries out the normal analyses associated with power station operation.

The Control Section maintains the computer and also checks and adapts the programmes if required.

The Calculation and Statistics Section uses the computer for producing station performance data and analysing plant performance.

There is no shift maintenance carried out in the French power stations, but an elaborate call out system operates and this is facilitated by the practice of providing housing for all the staff in French Power Stations. This housing is always rented to the staff who very often own a second home in another part of the country. There are Regionally based maintenance teams who are involved in the major outages which are based on a Regional programme. Preventative maintenance is used to a much lesser extent in the E. de F. where the attitude is "leave it alone if it is running well". However, monitoring of operating plant is carried out in order to identify potential trouble points. The French decision was based on some experimental work carried out at Porcheville and the experiments showed that the break down maintenance gave 2% greater availability at only half the cost of the preventative maintenance routine. The costs of maintenance in all French Power Stations are accurately assessed for each item of plant.

Some Regional Headquarters Working Patterns

This section is intended to be brief since the functioning of Regional Headquarters would comprise a substantial study in its own right. Many of the indirect effects of Headquarters work patterns have been considered as a part of the study of Systems in Chapter 7 . Regional Headquarters carries out three main functions and these are as follows:-

(a) The management and monitoring of Regional installations (mostly power stations). This also involves the subsidiary task of passing on much of this information to National Headquarters.

(b) The provision of supportive services to the Regional installations.

(c) The internal services required to sustain the Regional Headquarters as an entity.

Within the last two years, a restructuring of the Regional Headquarters has taken place in accordance with the National Policy of aligning the main functions in power stations under the three headings of Production, Engineering Services and Resource Planning. These three main functions are mirrored in their Regional Headquarters establishment and again at National Headquarters. In addition to these three Departments, the others at Regional Headquarters are the Scientific Services, Finance, Personnel and Secretarial. All of these are reflected in power station structures with the Scientific Services being represented by a Development Department and the other three are generally Sections within the Administration Department. As the newer power stations progress through the post commissioning phase it is generally foreseen that the Development Departments will become attenuated and finally cease to exist. For similar reasons this change could be matched at Headquarters by a move to combine the Scientific Services with the Engineering Services. These two Headquarters Departments differ from the others because their main function is to provide services and not a monitoring activity. These Departments are briefly described in the following paragraphs.

Scientific Services Department

Most of the problem solving work in the S.S.D. requires the application of scientific or engineering theory and the Department is sub-divided into these specialist sections.

Some specialist services are provided for the Region often involving the use of specialised equipment. Most of the S.S.D. work has arisen from direct contacts with locations and duplication of function is rare since the stations are normally not equipped with the necessary facilities. The National research laboratories provide similar facilities to those of the S.S.D., but generally the emphasis in these laboratories is on more fundamental research and investigations. Many of the S.S.D. projects finally emerge as engineering solutions and at this stage the project is either handed over to the power station or to the newly created Engineering Department. The main functions of the Scientific Services Department are set out in the following list:-

Chemistry and Materials Branch (M)

1. Chemical standards advice
2. Specialist chemical analyses
3. Plant chemical investigations and advice
4. Fracture, welding and corrosion problems (advice and test)
5. Metallic materials (test and advice)
6. Non-metallic materials (investigation, advice and test facilities)
7. Emissions (tests and advice)
8. Noise measurements and accoustics advice

Control and Instrumentation Branch (I)

1. Instrument evaluation and test service
2. Plant instrumentation (problems and advice)
3. Control systems (application of theory)
4. Computer controls (new technology)
5. General physics (scientific advice)
6. Nuclear physics (advice and problems)
7. Technical photography service

Engineering Branch (E)

1. Combustion and heat transfer technology
2. Rotating machinery vibration and stress
3. Stress measurements and advice
4. N.D.T. specialist support and facilities
5. Radiological safety advice
6. Plant inspection advice

Engineering Department

The Engineering Department was created to solve problems relating to specific plant areas. Such problems usually require modifications to existing plant. Specialist Engineers investigate the problems using theoretical knowledge and practical plant experience. These Engineers devise solutions to problems, but the engineering, contractual aspects and installation are dealt with by separate Sections within the Department. The various functions of the Sections are set out in the following list:-

Project Branch (P)

1. Preparation and awarding of contracts
2. Progressing contracts
3. Technical data to Project Group
4. User data correlation
5. Site supervision and commissioning of contracts
6. Tests, measurements and engineering liaison on location plant

Civil Branch (C)

1. Buildings design and modification
2. Stack and painting maintenance (contracts)
3. Stack and painting contracts (site supervision)
4. Civil engineering works and soil mechanics (design and problems)
5. Plant demolition (contracts and supervision)
6. Drawing Office services

Mechanical Branch (M)

1. Boilers (design and problems)
2. Auxiliary power station conventional plant (design and problems)
3. Steam turbines (design and problems)
4. Gas turbines (design and problems)
5. Auxiliary location rotating plant (design and problems)
6. Condensers (design and problems)
7. Nuclear fuel route (design and problems)
8. Nuclear safety systems (design and problems)
9. Plant reliability and performance data (collection and analysis)
10. Plant performance (analysis and advice)

Electrical Branch (E)

1. Static and transmission electrical plant (problems)
2. Rotating electrical plant (problems)
3. Control networks (design and problems)
4. Regulator problems

Electrical Branch (E) (Contd.)

5. Computer and control plant systems design
6. Transmission protection systems (problems design installation and calibration)
7. Communication systems (design problems and maintenance)
8. Metering equipment (design and problems)
9. Metering equipment (test and calibration)

One of the difficulties facing this Department is the existence on power stations of Development Departments and Engineering Services. Thus, the Department represents a change in C.E.G.B. policy which will make technical problem-solving a Headquarters function in a similar manner to that practiced in the American and Continental organizations. It is expected that the services provided by the Engineering Department will be restricted until such time as the power stations have run down substantial numbers of their engineering staff. At present there are approximately 250 professional Engineers in the Region's Power Stations carrying out plant modifications and developments.

Resource Planning Department

The Department is divided into three main Sections and their functions are displayed in the following list:-

System Operations Branch (O)

1. Operational statistics
2. Operational advice and technical information (policy making)
3. Liaison with Production Line Managers and Management Services Engineer and other Regions etc. London H.Q., Area Boards
4. Planning operations strategy
5. Reinforcement schemes
6. System development
7. Power system problems investigation service

Computer Branch (C)

1. Central computer service operation
2. Links with London H.Q. (functional)
3. Co-ordinate use of computers in S.W.R. (functional links, advice, etc.)
4. Develop new and improve existing systems

<u>Computer Branch (C)</u> (Contd.)

5. Support service to process control and data-logger computers at locations
6. Assessing and instituting advances
7. Software and hardware specialisms

<u>Management Services (S)</u>

1. Regional Planning Process (Promote, co-ordinate, maintain, improve)
2. Information Service
3. Economic Appraisals
4. Technical Audit
5. Work Study and C.W.M.
6. P. & P. Audit
7. Management Systems
8. Management Technology
9. Civil emergencies
10. Manpower planning models
11. New Power Station sites and plant retirements
12. Specialist planning advice for maintenance, commissioning, etc.
13. Organization changes
14. Operational Research
15. Monitoring Service
16. Reject Heat Usage

In each of the Branches the activities can be divided into two main categories namely -

(a) Routine day to day services

(b) Forward looking or predictive activities

Many of the services overlap the facilities in existing power stations and some have probably been overtaken by advancing technology, e.g. the advent of micro-processors and low cost location-based computers. The Systems Operation Branch is self-contained and a part of the National system. Many of the other activities are, in reality, systems and as such should be considered on their merits. Other activities of this Department overlap with other Departments:- e.g. Personnel Department (manpower planning), Finance (Economic appraisals).

Production Department

This Department provides some centralised services and also some monitoring functions. These are outlined in the following list:-

Fuel Supplies Branch (F)

1. Co-ordinating fuel movements
2. Fuel quality control
3. Price negotiation
4. Statistical records (supply, consumption and stocking)
5. Sale and disposal of PFA

Production Support Services (S)

1. Plant performance data
2. Performance testing advice
3. Reconciliation of coal stocks
4. Fault analysis
5. Reliability studies
6. Operational practice
7. Outage programming
8. Liaison (Manufacturers, PITB etc.)
9. Spares
10. Maintenance methods
11. Welders testing
12. Helicopter service
13. Gas turbine maintenance contracts
14. Operations requirements
15. Safety rules
16. Authorisations
17. Nuclear Services
18. Liaison with specialists
19. Briefs and reports
20. Budgets, plans
21. Admin. of safety rules, Departmental Instructions
22. Ownership schedules
23. Suggestion scheme

Many of the functions will probably be transferred to the Engineering Department when it becomes better established. In addition to these services the Production Department provides Line Management to all the stations by means of Group Managers. These Managers are now an intermediate level in the total management line and each has responsibility for a small group of five or six stations. When the system was originally established there were twice as many power stations in the Region and each Group Manager acted as a representative of the Station Managers on the Regional Management Committees. At that time their role was that of consultant and adviser and they did not exercise any line authority. The implications of this interposing of an additional level of authority are discussed in Chapter 9.

Personnel Department

This Department is divided into three main areas and these are shown in the following list:-

Field Services (F)

1. Recruitment
2. Manpower Planning
3. Organization Development
4. Staff Development
5. Appraisal

Industrial Relations (I)

1. Negotiating & Advisory Machineries
2. Briefs
3. Advice
4. Welfare & Catering

Education and Training (E)

1. Craft Apprentice Training
2. Training Centres
3. Adult Training

Many of the services provided are co-ordinating or monitoring services and others are as a representative body acting on behalf of the Region. In many cases the Department acts as a communication line between National Headquarters and the locations.

The Finance Department

The Finance Department comprises three main Branches who carry out the main functions in the following list:-

Management Control

1. Location budget control and monitoring
2. Statistics, trends and variances to senior management
3. Cost control and management accounting

Accounting Branch

1. Scheme assessments, D.C.F. rate of return, etc.
2. Detailed operating costs for Region
3. Regional cash flows (fuel materials and electricity)
4. Computer control programmes

Payments

1. Payment of all location wages and salaries
2. Provision of cash and banking facilities
3. Expense accounts monitoring
4. Invoice payments and collections

Many of the Finance Department functions provide a management monitoring service for all the activities within the Region. Other functions are services to locations such as the payment of wages and salaries either directly as in the case of engineering staff, or in the form of a pay-roll for the industrial staff. All invoices and payments (apart from local purchase orders) are handled by the Regional Service.

Secretarial Department

This Department provides many of the in-house services for the Regional Headquarters building,examples being typing, building facilities, stores, etc. The secretarial services which are Regional in nature are included in the following list:-

Purchasing and Stores

1. Stores control and financial stockholding
2. Advice on stores holdings and locations
3. Stores management and operation
4. The Regional main store (heavy goods)
5. A contract preparation advice to locations
6. Contract monitoring
7. Regional Purchasing services

Estates and Wayleaves

1. The maintenance of Estates and Wayleaves records
2. Management of all Regional properties
3. Negotiation of easements (wayleaves)
4. Purchase and planning permission for new sites
5. Disposal of surplus property and sites
6. Payments of rents
7. Advice and information to outside organizations (local authorities)

General Services

1. Legal advice
2. Insurance advice
3. Library services
4. Administrative services for public enquiries

As can be seen from the list, the main function of Secretarial so far as outside locations are concerned is the provision of the purchasing and stores facility. The Estates and Wayleaves service seldom affects on-going organizations.

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